U. S. DEPARTMENT OF COMMERCE NATIONAL BUREAU OF STANDARDS

RESEARCH PAPER RP881

Part of Journal of Research of the National Bureau of Standards, Volume 16, May 1936

ARC AND SPARK SPECTRA OF COLUMBIUM

By William F. Meggers and Arthur S. King *

ABSTRACT

A new description of conventional arc and spark spectra of columbium (niobium) in the wave-length range 2100 to 12000 A has been completed. Wave-length measurements are presented for 5700 lines, the majority to 7 significant figures, with an average probable error less than 0.005 A. Intensity comparisons of lines from the two types of sources permit an unambiguous separation of Cb I, Cb II, and Cb III or Cb IV spectra. These data should facilitate spectroscopic identification and analysis of columbium, and serve as a basis for further study of spectral structures, Zeeman effects, and hyperfine structures.

CONTENTS

I. INTRODUCTION

The literature on spectra of columbium (niobium) from 1868 to 1933 is listed and discussed in Kayser's Handbuch der Spectroscopie.[1] Since the total number of papers dealing in any way with the optical spectra of this element is less than 30, it can properly be said that columbium has been neglected. No comprehensive and accurate measurements of wave lengths have been published for columbium in the past 25 years, and Kayser, who quotes all available data for these spectra, states "Die Tabelle von Nb (Cb) ist weit davon entfernt, vollständig zu sein, obwohl die Zahl der gemessenen Bogen- und Funkenlinien etwa 4500 beträgt."

A dozen years ago one of the present authors became interested in a term analysis of columbium spectra, and with the aid of data then available succeeded in finding a few multiplets in the Cb I[2] and Cb II[3] spectra. The impossibility of extending such analyses without improved and additional descriptive material was responsible for investigation of furnace spectra,[4] for remeasurement of the arc and spark spectra,[5] and for further observations of Zeeman effects. These new data have greatly advanced the term analyses,[6] and remeasurement

* Mt. Wilson Observatory, Pasadena, Calif.

[1] H. Kayser, Handbuch der Spectroscopie **6**, 128-159 (S. Hirzel, Leipzig, 1912); **7**, 1397-1446 (S. Hirzel, Leipzig, 1934).
[2] W. F. Meggers, J. Wash. Acad. Sci. **14**, 442 (1924).
[3] W. F. Meggers and C. C. Kiess, J. Opt. Soc. Am. **12**, 417 (1926).
[4] A. S. King, Astrophys. J. **73**, 13 (1931).
[5] A. S. King and W. F. Meggers, Phys. Rev. [2], **37**, 226 (1931).
[6] W. F. Meggers and B. F. Scribner, NBS J. Research **14**, 629 (1935) RP793.

of the spectra now permits satisfactory spectroscopic identification and analysis of columbium.

Although discovered in 1801, columbium for more than a century remained a chemical curiosity, and has been one of the latest to find industrial application. Just recently, it has been given an important use in the steel industry. The metal when alloyed in moderate and economical proportions with the austenitic chromium-nickel steels inhibits intergranular corrosion, and is expected to give fresh impetus to industrial utilization.[7] A ton a day is now being refined and used for this purpose. Since this is likely to continue and since also the use of spectra for chemical identification and quantitative analysis is developing rapidly, it will not be long before practical spectroscopists will be wishing for a satisfactory description of columbium spectra. It is primarily in anticipation of such demand that we offer the following table of arc and spark spectra, which may also serve as a basis for further work on term analysis, Zeeman effects, hyperfine structure, etc.

II. EXPERIMENTAL

All former observers of columbium spectra were forced to use more or less impure salts and carbons, because metal of high purity has been produced only recently. The electrodes used for the production of spectra herein to be described were solid rods of columbium metal about 1 cm in diameter, kindly presented for spectroscopic investigations by C. W. Balke in 1929. A second pair of electrodes was generously supplied by Balke in 1931. These columbium rods contained a considerable amount of tin and a trace of iron but were otherwise spectroscopically pure. It is remarkable that none of the observed spectral lines could be identified with the chemically homologous elements, vanadium and tantalum. Most of the known lines of tin appeared on our spectrograms, but they were removed from the final list. The strongest lines of iron showed faintly in the columbium spectrograms and were not measured except as wave-length standards.

The arcs were operated with direct current of 5 or 6 amperes, the applied potential being 220 volts. The sparks were produced by supplying transformers with 50 or 60 cycle alternating current and connecting the electrodes to the secondary (10,000 or 40,000 volt) terminals, with mica or glass condensers in parallel.

For recording these spectra, special photographic plates were selected for different spectral regions. The middle portion (2700 to 6700 A) was photographed in 1930 on Eastman and on Ilford plates. Hilger Schumann plates were used in the ultraviolet, and observation of the infrared was improved and extended from time to time by applying new types of sensitized plates supplied by the Eastman Kodak Co.[8] The entire range now accessible to photography with large-scale spectrographs in air has thus been studied. Description and analysis of these spectra are being extended in the extreme ultraviolet by R. J. Lang,[9] employing vacuum spectrographs.

In making a new description of columbium spectra, we aimed to strive for satisfactory precision of wave-length measurements, and sufficiently accurate estimates of relative intensities to permit differ-

[7] F. M. Becket and R. Franks, Trans. Am. Inst. Mining Met. Engrs., Iron and Steel Div. **113**, 143 (1934).
[8] Photographic Plates for Use in Spectroscopy and Astronomy (Eastman Kodak Co., March 1935).
[9] R. J. Lang, Zeeman Verhandelingen, p. 44 (1935).

entiation of ionization stages. To obtain the first objective in such complex spectra as those characteristic of columbium, large spectrographs with adequate resolving power and freedom from false spectra or ghosts must be employed. In this particular case, however, the resolving power should not be so great as to cause confusion of hyperfine structure with ordinary line structure neglecting nuclear effects. The spectrographs actually employed in these observations are described in table 1.

TABLE 1.—*Spectrographs used for description of* Cb *spectra*

Spectral region	Spectrograph	Maker	Dispersion
A			A/mm
2100 to 2700	NBS quartz prism	Adam Hilger	0.4–1.1
2600 to 5400	MW concave grating 2d order	Anderson	1.8
5300 to 7700	MW concave grating; 1st order	do	3.7
6700 to 9000	NBS concave grating; 1st order	Rowland	3.5
8800 to 10000	do	Wood	5.1
9000 to 12000	do	Anderson	10.2

The Hilger quartz spectrograph is an efficient autocollimating instrument of about 3-m focal length so constructed that the dispersion and resolving power are equivalent to those obtained from three 60° prisms, each with 20 cm base thickness.

The Mount Wilson concave-grating spectrograph is the vertical adaptation of the Rowland mounting described in another paper.[10] This grating has 15,000 lines per inch and a radius of 15 feet.

Each of the National Bureau of Standards gratings has a radius of curvature of 21.5 feet, but the number of lines per inch is 20,000, 15,000, and 7,500 in the order listed. Each performs stigmatically since the grating is illuminated with a (stainless steel) mirror having the slit at its principal focus, and observations are made on or near the normal to the grating.[11] The NBS Rowland grating has practically the same scale and power as the MW Anderson grating, but its "Rowland ghosts" are so strong in the second order that it is unsatisfactory for use on fully exposed complex spectra. For this reason, after the work on furnace spectra of columbium had shown the superiority of the MW grating, the authors arranged this cooperative program to produce a new description of columbium spectra. A large number of spectrograms, covering the visible and near ultraviolet, were made at Mount Wilson, and supplemented by others secured at the National Bureau of Standards for description of the infrared and shorter ultraviolet. The best spectrograms were selected for measurement at the National Bureau of Standards, where all the actual measurements and calculations were performed. The authors are indebted to B. F. Scribner for executing a considerable portion of the calculations.

To facilitate intensity comparisons most of the spectrograms record arc and spark spectra of columbium on the same plate, with a comparison spectrum of iron between. Other spectrograms of arc or spark alone (each with iron comparison) were prepared so that wave-

[10] A. S. King, Astrophys. J. **40**, 19 (1914).
[11] W. F. Meggers and K. Burns, BS Sci. Pap. **18**, 191 (1922).

length measurements could be made of each without bias on account of the other. It is well known that lines enhanced in a high-potential condensed spark are, in general, more diffuse than arc lines, and almost invariably appear to be displaced toward longer waves. These phenomena, ascribed to Stark effect, make it difficult to determine the true wave lengths. For spark lines which appear in the arc, we have decided to publish only the values derived from arc spectra. Corresponding values from spark spectrograms are larger by various amounts up to 0.02 or 0.03 A, the difference usually increasing with degree of enhancement of the line. Unfortunately, it is not possible to give the true values of lines which appear only in the spark, but it may be assumed that the majority of them are at least 0.02 to 0.03 A; too large on account of Stark effect.

Each spectrogram was measured in both directions and each line finally retained was observed on two to nine plates. Altogether this labor of measuring columbium spectra relative to iron standards involved more than 100,000 microscopic bisections of spectral-line images. For purposes of calculation each spectrogram was divided into parts so that the maximum deviations from standards never exceeded ± 0.02 A. Prism spectrograms were reduced with Hartman's interpolation formula,[12] while grating spectrograms were assumed to have constant dispersion over short intervals.

The standards employed were the international iron arc secondary standards of wave length.[13] supplemented in the ultraviolet by observed and computed values published by Burns and Walters.[14] Since these standards have probable errors or one or more units in the seventh figure, it may be questioned if it is legitimate to retain more than six figures in comparison measurements. In the present case, we have kept the seventh figure only when the average deviation from the arithmetical mean of two or more observations is less than 0.005 A. Actual computation of probable errors for random lines with four observations on second order grating spectrograms indicate an average probable error of ± 0.002 A. A practical test of these wave lengths was presented in a paper on multiplets and terms in the first two spectra of columbium,[15] in which it was shown that the average deviations of an observed wave number from the corresponding term combination is ± 0.02 cm^{-1} for 413 classified Cb I lines, and ± 0.04 cm^{-1} for 255 classified Cb II lines. If the average wave length of each group is considered, it will be seen that in each case the deviations correspond to wave-length errors less than ± 0.005 A. It is perhaps surprising that the fit should be so good in view of the fact that many lines have hyperfine structure widths of 0.2 to 0.5 A. The width of 8320.93 A exceeds 1.0 A. For all unresolved complex lines we give values corresponding to the centers of gravity only, but these values usually represent the mean of edge measurements in the case of the wider lines.

[12] W. F. Meggers, Dictionary of Applied Physics **4**, 890 (1923).
[13] Trans. Int. Astron. Union **3**, 86 (1928).
[14] K. Burns and F. M. Walters, Jr., Pub. Allegheny Obs. **6**, 159 (1929).
[15] W. F. Meggers and B. F. Scribner, NBS J. Research **14**, 629 (1935) RP793.

III. RESULTS

Our results for arc and spark spectra of columbium from 2100 to 12000 A are presented in table 2, which contains 5700 lines. The lines are represented by wave lengths followed by estimated relative intensities of arc and spark images, and descriptive symbols. An effort was made to maintain a fairly uniform and expanded scale of intensities comparable with that adopted in the description of furnace spectra.[16] Toward 2100 A the arc intensities may be too large for lines characteristic of ionized atoms on account of projecting the image of a short arc with a simple quartz lens, thus bringing light from the electrodes into the spectrograph. In general, however, a comparison of intensities from arc and spark sources differentiates without ambiguity Cb I, Cb II, and Cb III spectra. Lines from neutral columbium atoms, yielding the Cb I spectrum, can be recognized by outstanding strength in the arc. Lines from singly ionized atoms constitute the Cb II spectrum, and although many of these appear in the arc, they are generally enhanced in the spark, the degree of enhancement being proportional to the excitation energy required to produce them. Many Cb II lines do not appear in the arc at all, and are more or less hazy and unsymmetrical in the spark. A small proportion of the lines excited only in the condensed spark are enhanced at the electrodes. It is fairly certain that all lines marked "e" in table 2 belong to doubly or to trebly ionized atoms, but our observations do not permit a differentiation between Cb III and Cb IV spectra. A study of the relative intensities of these lines when self-inductance is introduced in the discharge circuit might lead to a separation of these higher ionization stages.

Columbium spectra are characterized by an exceptional richness in number and variety of lines. Throughout the ultraviolet the average line density is 2 per angstrom unit, and in some regions as large as 6 lines per A. In the visible and infrared, where the line density appears to be smaller, many atomic lines may be masked by molecular spectra (presumably due to CbO), which are very prominent in the conventional atmospheric sources. A few faint band heads are recognized in the blue, stronger ones in the orange, but the most intense ones are found in the red and infrared. Each band head is accompanied by a dense background of partially resolved rotation structure, among which it is practically impossible to recognize fainter atomic lines. Although these molecular spectra are not so intense in spark spectrograms, if the latter are exposed sufficiently to record all arc lines, the bands are developed with equal intensity. Perhaps these molecular spectra can be eliminated in vacuum sources or in Paschen hollow-cathode discharges. Practically all details of molecular spectra except band heads have been omitted in table 2.

A striking feature of columbium spectra, first mentioned[17] in 1931, is the hyperfine structure. Although almost none of this is resolved by the spectrographs employed in this work, a large proportion of the spectral-line images appear to be sharp-edged and flat-topped, indicating that the images are formed by two or more close components. In some patterns incipient resolution was suggested on one side or the other, giving the impression that they

[16] A. S. King, Astrophys. J. **73**, 13 (1931).
[17] A. S. King, Astrophys. J. **73**, 13 (1931).

might all be so-called "flag-patterns" in which both intensity and separation of components decrease regularly in one direction or the other. Except for a symbol "*c*" denoting complex hyperfine structure suggested by our spectrograms, we have omitted further details of these phenomena. In some instances the symbols "*d*" and "*h*" may also represent hyperfine structure, since it is often difficult to make absolute distinctions of this kind. This hyperfine structure of columbium lines has been studied in some detail by Ballard,[18] who deduces from it a nuclear spin moment of $I=9/2$ for columbium atoms.

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)

c=Complex, hyperfine structure (*hfs*).
d=Double, may be *hfs*.
e=Enhanced at electrode.
h=Hazy.
H=Very hazy.
l=Shaded or displaced to longer waves.
v=Shaded or displaced to shorter waves.
B=Band head.
p=Part of band structure.
r=Narrow self-reversal.
R=Wide self-reversal.

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
2102.13	2	—	2137.055	15	20	2158.135	20	10
2103.59	20	10	2137.546	20	40	2160.269	50	100
2107.267	40	30	2138.42	3	4*h*	2160.340	20	40
2108.23	2	1	2138.552	2	—	2161.54	5	—
2108.34	2	1	2138.89	5	6	2162.63	2	1
2109.428	100	150	2140.39	15	10	2163.076	10	5
2110.05	10	10	2140.48	3	1	2163.821	5	3
2110.96	2	1	2142.02	5	5	2164.26	2	2*h*
2111.17	2	1	2142.52	2	1	2166.77	5	—
2112.30	—	6*he*	2142.91	6	5	2167.241	40	50
2113.084	50	50	2143.20	4	4	2168.188	4	2
2114.77	2	1	2143.64	1	—	2169.892	10	15*h*
2115.16	—	1*h*	2144.17	—	9*he*	2170.718	4	5*h*
2116.387	10	5	2144.487	4	2	2171.03	1	—
2118.873	30	20	2144.79	4	2	2172.40	3	4
2119.06	5	5	2146.14	—	15*He*	2172.48	2	1
2119.63	3	1	2146.358	—	50*He*	2175.555	8	—
2119.98	2	1	2147.197	40	20	2175.844	30	40
2120.52	5	3	2148.650	30	10Sn?	2176.761	40	50
2121.63	—	6*he*	2148.726	2	—	2176.986	2	—
2122.67	—	20*he*	2149.03	5	5	2177.25	—	20*h*
2122.73	4	—	2149.539	30	20	2177.36	1	—
2124.33	5	5	2152.05	4	4	2178.07	3	—
2125.209	50	60	2152.57	1	1	2178.225	4	—
2126.541	50	60	2153.30	2	3	2180.670	10*c*	10*c*
2127.35	2	—	2153.556	3	1	2185.398	4	4
2128.12	2	1	2153.61	—	3*h*	2185.872	1*c*	2*c*
2128.21	2	1	2154.207	20	10	2187.036	—	3*h*
2129.00	2	1	2154.474	5	6	2188.138	—	5*h*
2129.69	3	2	2154.73	2	—	2188.944	7	—
2130.23	—	25*he*	2154.91	1	1	2192.414	6	7
2131.181	50	60	2155.13	2	2*h*	2193.011	8	—
2132.03	1	—	2155.621	25	40*h*	2193.805	10	—
2132.83	7	6	2155.59	1	—	2195.660	—	2*H*
2133.17	2	1	2156.21	—	10*he*	2195.74	4*h*	—
2133.67	3	1	2156.27	2	—	2195.77	—	15*h*
2134.492	20	15	2156.40	2	—	2195.83	3*h*	—
2134.710	30	40	2156.736	40	20	2196.39	—	20*h*
2134.952	15	20	2157.27	6	8*h*	2196.84	2	—
2135.32	1	—	2157.48	2	1	2198.33	—	1*H*

[18] S. S. Ballard, Phys. Rev. **46**, 806 (1934).

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
2199.04	1	2*h*	2237.496	80	100	2269.653	4	—
2199.603	5	8*h*	2238.14	1	2	2269.865	10	80*h*
2199.969	25	100*h*	2238.518	80c	1	2270.180	40	120*h*
2200.218	4	—	2240.31	—	60*He*	2270.65	—	2
2201.362	—	6*h*	2240.645	15	50*hl*	2272.730	40	80
2201.916	3	—	2241.011	2	15*hl*	2273.120	—	6*h*
2202.007	6	7	2241.855	8*h*	—	2273.566	60	120*h*
2203.170	5	6	2242.294	20	3	2273.91	—	100*He*
2203.555	3	—	2242.579	40	50*hl*	2274.128	50	100*h*
2203.637	60	150*h*	2242.958	20	—	2274.198	10	50*h*
2204.617	12	—	2244.184	—	50*He*	2274.770	9*h*	—
2205.230	2	—	2244.29	1	50*H*	2275.219	—	150*He*
2206.016	—	40*He*	2244.92	—	4*h*	2276.170	4	6
2206.639	1	4*h*	2245.15	1	2	2276.223	4*h*	—
2207.182	10	20*h*	2245.26	—	2	2276.361	3	3
2210.31	—	2*h*	2246.176	90c	.1	2277.426	15	—
2210.442	6	—	2246.421	8c	—	2277.586	2	—
2210.534	15	40*h*	2246.500	2	15*h*	2278.320	—	4*h*
2210.622	7	—	2246.752	—	100*He*	2278.477	—	4*h*
2210.917	15	20*h*	2246.98	1	10*h*	2279.386	—	80*He*
2211.274	3	6*h*	2247.188	4	4	2279.414	2	—
2211.46	50c	—	2247.997	80	1	2280.450	40	50
2212.222	2	—	2248.282	2	60	2280.912	1	—
2212.927	—	3*h*	2248.84	—	50*He*	2281.136	7	20
2214.034	40c	—	2249.52	—	60*He*	2281.505	—	200*He*
2215.29	3	4	2250.005	2	6*h*	2281.830	5	80*h*
2215.54	30c	—	2250.308	100c	2	2283.004	100	200
2217.18	—	10*He*	2250.463	20	60*hl*	2283.377	4*h*	1
2217.24	4*h*	10*H*	2251.39	2*h*	—	2284.356	3	9*h*
2217.872	15	—	2251.51	4*h*	—	2284.41	—	70*He*
2218.357	3	—	2252.09	2	—	2285.223	40	60*h*
2219.163	3	5*h*	2252.210	25	200	2285.673	—	5*h*
2219.328	3	10*hl*	2252.623	4	15	2286.352	2	8*h*
2220.184	70c	2	2252.754	2	—	2286.749	1	15
2220.277	—	5*h*	2253.31	—	2*h*	2286.892	7	7
2220.417	—	4*h*	2253.802	8	—	2287.02	—	6*He*
2221.415	1	4	2254.564	150	2	2287.504	5*h*	—
2221.474	2	1	2254.953	20	40	2288.861	10	30*h*
2221.70	—	4*He*	2255.175	1	3*h*	2289.840	5*h*	—
2223.672	60c	—	2255.597	80	150	2290.289	6	6
2224.667	20	30*hl*	2255.791	5	—	2290.39	—	150*He*
2225.096	—	10*He*	2256.075	6	—	2291.383	8	6
2225.235	6	—	2257.537	10	40*hl*	2291.644	2	20*h*
2225.343	50	1	2257.886	160	2	2292.325	—	8*hl*
2225.547	3	5*hl*	2260.854	20	—	2293.145	2	6*h*
2226.927	15	—	2261.531	2	15*h*	2293.274	6	—
2227.280	10	—	2261.721	7	7*h*	2293.41	—	3*He*
2227.706	150c	3c	2262.132	15	60*h*	2293.926	12	40*hl*
2228.032	100c	2c	2262.34	1	2	2294.41	—	4*He*
2228.39	4	—	2263.219	4	12*h*	2294.484	2	—
2229.65	30	—	2263.312	8	10*h*	2294.71	—	5*He*
2229.716	30	100*h*	2264.074	5	3*h*	2294.983	6	50*h*
2230.74	1*h*	4*h*	2264.354	3	—	2295.681	100	250
2230.85	1*h*	8*h*	2264.556	20	120*h*	2295.972	6	8
2231.428	8	—	2265.217	4	—	2296.748	2	3*h*
2232.545	80c	1	2265.489	2	—	2297.611	15	50*h*
2233.172	9	—	2265.592	—	50*He*	2297.853	2	40*h*
2233.54	—	10*h*	2265.676	40	100*hl*	2298.385	8	10
2235.66	1	2*h*	2266.732	20	100*hl*	2298.662	7	5
2235.89	1	2*h*	2267.44	—	3*He*	2299.226	8	20*h*
2236.22	10	—	2268.287	2*h*	—	2300.295	6	—
2236.43	1	4*h*	2268.527	60*h*	100*h*	2300.339	10	30*h*
2236.724	20	40*h*	2268.59	3	—	2300.519	4	5*h*
2236.95	1	5*h*	2269.202	1	10*h*	2300.785	40	50
2237.30	—	10*hl*	2269.535	4	—	2300.854	8	—

TABLE 2.—*Arc and spark spectra of columbium (Z=41)*—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
2302.086	100	200	2335.322	15	20	2364.270	—	3*h*
2302.695	30	40	2335.620	6	30	2364.325	5*h*	—
2303.154	2	4	2336.410	7	—	2365.215	30	70
2304.26	1	—	2337.603	1	—	2365.305	3	4*h*
2304.363	—	7*He*	2337.744	20*c*	—	2365.624	2	20*h*
2304.77	—	40*He*	2338.091	—	40*He*	2365.745	1	10*h*
2305.29	3	—	2338.38	2	—	2365.940	3	—
2305.426	—	4*h*	2338.42	2	—	2666.198	1	20*h*
2305.975	4	—	2338.730	4	—	2366.715	1	—
2306.59	1	—	2339.58	—	4*H*	2367.367	—	5*H*
2307.477	3	3	2339.876	2	—	2368.64	3	—
2307.759	3	—	2340.025	2	20*h*	2368.860	15	—
2308.807	6	5	2340.149	8	—	2368.941	1	9*h*
2309.239	60	100	2340.277	10	—	2369.954	30	100
2309.742	3	4	2340.931	2	—	2370.732	—	4*H*
2309.93	—	15*H*	2341.152	3	—	2372.227	4*c*	8*c*
2310.313	2	8*h*	2342.852	1	4*h*	2372.730	4	50*he*
2310.570	2	2	2343.103	1	3*h*	2373.074	3	—
2311.456	4	20*h*	2343.271	10	8	2373.967	4*c*	10*c*
2311.676	7	—	2343.66	—	3*H*	2374.167	1	8
2313.171	2	—	2344.075	3	?	2374.459	1	—
2313.31	—	200*H*	2344.12	—	15*He*	2374.924	2	—
2313.370	1	—	2344.517	15*c*	—	2376.398	30	100
2313.524	15	10	2344.640	8*c*	—	2377.989	2	15
2314.240	1	3*h*	2345.333	2	15*h*	2378.476	2	4
2314.359	4	—	2346.532	25	40	2378.935	2	—
2314.850	30	50	2346.679	10*c*	—	2379.122	—	5*h*
2315.173	20	15	2346.961	—	3	2380.148	1	10*h*
2316.271	3*h*	—	2347.111	—	1	2381.122	1	2
2316.929	6	15*h*	2348.639	—	5*H*	2381.717	4	4
2317.784	10	10*h*	2348.756	10*c*	—	2382.246	4	—
2318.180	—	3*h*	2349.217	—	40*He*	2382.79	—	1*h*
2318.432	5	—	2349.411	—	5*h*	2383.843	2	—
2319.589	15	25*h*	2350.034	6	—	2384.208	—	3*H*
2319.847	3	5*h*	2350.488	8	20*h*	2384.827	2	—
2320.238	25	20*h*	2350.710	2	—	2384.852	—	5*h*
2320.659	2	8*h*	2351.613	2	4	2385.251	2	10*h*
2321.271	—	3*h*	2351.677	4	—	2386.406	2	—
2321.489	4	—	2352.055	2	—	2387.101	20	80
2321.621	2	—	2352.131	3	—	2387.399	—	50*H*
2321.996	20	30*h*	2352.338	20	60*h*	2387.521	30	90
2322.992	8*h*	—	2352.837	30	60*h*	2388.269	20	40
2323.512	2	15*h*	2353.510	6	—	2390.080	2	—
2323.654	3	—	2353.765	2	4	2390.385	—	2
2323.884	1	—	2353.80	10	—	2390.454	4	—
2323.959	1	—	2354.040	15	50	2390.718	—	2*h*
2324.063	8	40*h*	2354.470	9	—	2391.912	5	20
2324.237	40	50*h*	2354.941	—	3*h*	2392.932	1	—
2324.409	1	3*h*	2355.533	—	20*He*	2393.110	2	—
2324.600	4	—	2355.680	8	6	2394.058	5	—
2325.504	2	6*h*	2356.005	10	30	2394.395	4	—
2326.221	5	30*h*	2356.290	15	40	2394.697	1	2
2326.964	3	—	2357.437	1	3	2395.329	20	40
2327.131	10	15*h*	2358.134	5	—	2395.824	1*c*	8*c*
2327.521	—	4*h*	2359.679	3	—	2396.310	—	3*c*
2328.028	3	5*h*	2360.302	20	70	2396.772	3*c*	2
2328.077	4	—	2360.794	2	—	2397.175	—	2
2328.222	5	—	2361.051	—	10*He*	2397.558	1	4*c*
2330.202	—	10*He*	2362.046	—	60*He*	2397.677	2	2
2331.224	2	—	2362.489	—	30*He*	2397.967	4	6*h*
2332.295	—	4*h*	2362.50	3	—	2398.484	30	120
2332.704	—	2	2363.062	4	—	2398.768	1	2
2332.896	10	10	2363.587	2	4	2399.718	5	—
2333.650	10	—	2363.716	2*h*	—	2400.054	2	—
2334.488	2	—	2363.852	4*h*	—	2400.910	5	—

TABLE 2.—*Arc and spark spectra of columbium* ($Z = 41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
2401.040	2	4	2427.627	2	—	2453.367	20	1
2401.272	—	4	2427.714	1	—	2453.853	8	15
2401.873	3	—	2428.047	3	—	2453.945	7	15
2402.339	8c	—	2428.096	3	—	2454.057	—	4*H*
2402.658	—	8*h*	2428.603	2	8*h*	2454.163	2	—
2403.107	4	—	2428.848	3	—	2454.376	—	4*h*
2403.918	4	—	2428.880	—	20*He*	2454.592	1	—
2404.210	2	20*h*	2430.310	1	4*h*	2455.534	—	5*He*
2404.278	—	15*he*	2430.442	2	—	2455.872	3	—
2404.895	—	50*H*	2431.679	3c	30c	2456.676	3c	6c
2405.344	25c	50c	2432.321	5c	10c	2456.83	1	—
2405.576	2	—	2432.822	1c	8c	2456.999	—	400*He*
2405.850	30c	60c	2433.56	—	8*He*	2457.243	—	50*He*
2406.942	10	1	2433.680	10	—	2458.083	10	40*h*
2407.685	6	20*h*	2433.792	15	60*hl*	2458.310	—	8*He*
2408.056	2	—	2434.117	—	1	2458.575	5	—
2410.080	1	6*h*	2434.310	1	—	2459.290	1	—
2410.285	10c	20c	2434.391	1	—	2459.434	1	2
2410.792	3*h*	—	2434.662	—	3	2459.563	2	8*h*
2411.235	—	5*h*	2434.878	4*h*	—	2460.398	—	100*He*
2412.283	—	5*h*	2434.962	6	—	2461.174	4c	9c
2412.460	40	150*h*	2435.074	2	10*h*	2461.757	10	—
2412.645	5	—	2435.374	2	5*h*	2462.047	2	60
2412.805	1	30*hl*	2435.952	15	50*h*	2462.500	2c	4c
2413.936	—	200*hl*	2436.252	2	—	2462.889	20	1
2414.206	7	—	2436.329	12	2	2463.631	5	—
2414.485	—	150*hl*	2437.08	—	1	2463.732	—	10*He*
2414.762	2c	—	2437.161	9	1	2464.432	10	—
2414.876	—	6*H*	2437.411	20	50	2464.648	1	15*h*
2415.678	1	—	2437.721	—	15*He*	2465.199	—	4*h*
2415.955	5c	10c	2437.924	3	—	2465.709	2*h*	—
2416.169	15	30	2438.110	1	—	2466.318	10	—
2416.247	2	3*h*	2439.445	2	—	2466.563	2	9
2416.679	2	2	2439.715	3	—	2466.727	25	1
2416.994	40	150*h*	2440.392	5	—	2467.630	3	—
2417.157	—	20*hl*	2440.976	3	8	2468.035	—	2*h*
2417.323	8	15*h*	2441.021	2	—	2468.064	1	—
2418.05	2*h*	—	2441.224	—	2*H*	2468.734	—	60*He*
2418.168	2	—	2441.856	10c	30	2469.072	25	1
2418.490	3	—	2442.144	15	40	2469.403	—	50*He*
2418.687	30	150*h*	2442.677	7	40	2470.647	2	—
2418.792	4	—	2443.104	2	—	2471.25	1	—
2419.467	4	10*h*	2443.529	8	1	2471.318	5c	20c
2419.804	6	—	2443.718	2	2	2472.376	5	20
2419.976	5c	—	2444.479	3	10	2472.981	—	2*h*
2420.144	7	—	2444.856	—	3*h*	2473.752	2	—
2420.461	2	—	2445.066	20	2	2474.187	—	3*h*
2421.016	2	2	2445.172	1	—	2474.655	15	—
2421.914	—	150*H*	2445.402	2	2	2474.82	—	8*H*
2422.900	3	—	2445.832	—	30*H*	2475.881	—	50*He*
2422.976	1	2*h*	2445.913	1	—	2476.478	7	—
2423.064	—	3*H*	2446.080	—	20*He*	2477.379	50	150
2423.532	—	4*h*	2446.130	10	—	2477.720	1	—
2423.996	4	—	2446.439	—	30*He*	2477.936	5	20
2425.112	1	5*h*	2446.764	—	2	2478.283	20	60
2425.337	2	—	2447.413	4	—	2478.567	—	4*h*C?
2425.741	5	—	2447.966	8	15	2479.351	1	—
2426.128	—	4*h*	2448.258	2c	20c	2479.454	—	1
2426.243	1	5*h*	2450.069	1	5	2479.933	25	80
2426.637	6*h*	—	2450.250	3	10	2481.434	2	—
2426.794	—	50*Hl*	2450.433	7	12	2483.721	5	15
2426.957	5	—	2450.900	1	2	2483.878	15	50
2427.105	3	—	2451.870	15	60	2484.931	4	30
2427.536	9	1	2452.468	—	2	2485.420	2	9
2427.570	—	2*H*	2453.084	20	1	2486.028	—	30*He*

TABLE 2.—*Arc and spark spectra of columbium (Z=41)*—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
2488.234	3	6	2530.103	1	2	2562.402	40	120
2488.746	—	40*He*	2530.168	1	3	2563.913	5	10
2489.112	2	—	2530.658	2	1	2564.070	3	15
2489.466	—	2	2530.968	15	80*h*	2564.265	4	—
2490.111	1	20*h*	2531.252	5	30*h*	2564.526	1	1
2490.217	2	25*h*	2533.188	6*c*	30*h*	2564.735	8	4
2490.848	—	40*He*	2533.914	—	20*He*	2564.846	3	15
2490.988	—	15*He*	2534.445	2	10*He*	2565.098	1	—
2492.115	—	1	2534.70	—	2*He*	2565.410	30	3
2492.424	1	—	2534.83	—	2*He*	2565.504	2	20
2493.020	—	40*He*	2535.259	1	—	2565.675	1	4
2493.670	—	1	2536.580	—	1	2566.075	5	40*He*
2494.801	3	—	2538.055	6	1	2567.281	3	—
2495.204	1	—	2539.128	1	—	2567.42	—	15*He*
2496.806	—	3	2539.224	3	10	2567.510	20	2
2496.976	2	4	2539.464	1	—	2568.409	7	10
2497.464	2	—	2540.611	20	80*h*	2568.677	1	2
2498.244	3	30	2540.811	1	3	2569.030	20	2
2498.365	1	—	2541.017	2	—	2569.187	1	4
2499.282	2	—	2541.074	1	2	2569.796	1	—
2499.750	—	300*He*	2541.140	1	—	2570.782	6	1
2500.426	4	10	2541.424	40	50	2571.054	7	1
2501.41	—	150*He*	2541.704	2	—	2571.324	25	60
2502.496	10	40	2541.972	5	—	2571.74	—	1*h*
2502.944	4	—	2542.925	1	—	2572.099	15	1
2503.431	1	2	2543.252	3	—	2572.80	1	—
2504.250	—	8*He*	2543.980	10	1	2573.022	3	5
2504.648	30	2	2544.435	1	1	2573.136	2	20
2504.948	1	3*h*	2544.723	2	—	2573.914	—	4*He*
2505.911	2	4	2544.802	50	200*R*	2574.074	3*c*	5
2507.134	6	1	2545.404	—	2	2574.843	5	40
2508.535	—	30*He*	2545.633	—	200*He*	2575.570	1	2
2508.601	2	—	2546.353	1	2	2575.968	2	6
2511.004	30	120*h*	2547.556	1	2	2576.592	7	1
2511.573	3	—	2548.634	8	30*h*	2578.086	4	—
2511.970	—	40*He*	2549.039	—	1	2578.203	8	1
2513.273	2	—	2549.435	1	2*h*	2578.734	50	3
2514.352	6	6	2549.904	7	—	2580.284	6	40
2514.500	1	1	2550.037	1	2	2581.194	7	1
2514.750	1	—	2550.878	2	—	2581.465	1	—
2514.784	3	—	2551.382	50	120*h*	2581.971	2	—
2515.775	4	—	2552.014	—	4*He*	2583.103	15	1
2516.878	1	—	2553.490	3*c*	15*h*	2583.219	8	1
2517.487	2	10*h*	2553.752	3	—	2583.982	50*c*	250*R*
2517.658	—	2*H*	2554.103	12	1	2584.450	1	1
2519.018	2	—	2554.793	3	8	2586.087	—	50*He*
2519.692	3*c*	12*c*	2555.107	3	—	2586.911	2	4
2519.841	2	5	2555.314	3	8	2587.409	2	8*h*
2520.507	10	1	2555.626	20	60	2587.952	5*c*	3
2520.663	—	2*h*	2556.933	40	120	2588.36	1	—
2521.404	40	150*h*	2557.41	4	—	2588.966	3	9
2521.805	2	—	2557.942	—	100*He*	2589.264	5	1
2521.880	2	—	2557.973	1	—	2590.940	50	200*R*
2521.924	3	—	2558.628	1	3	2592.035	4	3
2522.341	3	8	2558.765	1	—	2592.190	50	4
2522.885	—	3*h*	2558.835	2	—	2592.911	4	2
2523.761	2*c*	5*c*	2558.936	20	2	2593.530	1	—
2524.985	10	1	2559.05	1	—	2593.764	—	60*He*
2525.202	1	—	2559.436	—	2*h*	2594.337	10	9
2525.610	2	—	2560.112	3*c*	6*c*	2594.685	4	—
2525.806	20	100*h*	2560.622	5	20	2594.736	15	50
2527.277	4	3	2560.741	2	3	2594.964	3*c*	4*c*
2527.914	5	25	2561.465	2*c*	2*c*	2596.498	2	—
2528.208	1	—	2561.708	5	6	2596.96	—	20*He*
2529.300	1	2	2561.926	—	1	2597.138	10	1

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
2597.74	—	20*He*	2631.442	1	3*h*	2664.010	2	3
2598.037	2	6	2632.510	20	60*h*	2665.247	20	80
2598.882	—	100*He*	2633.153	—	80*He*	2666.058	—	2
2599.522	—	3*h*	2633.795	—	1	2666.164	1	3
2600.156	4	10	2633.981	2	—	2666.595	30	50
2600.615	1	2	2634.154	—	20*He*	2667.07	2c	4
2601.285	25	100	2634.493	1	—	2667.146	3	10
2601.597	3	—	2634.704	10	2	2667.300	20	30
2601.832	7	1	2634.890	2	—	2667.765	12	35
2602.011	8	1	2635.512	1	—	2667.996	2	4
2602.485	3	4	2635.837	—	3*h*	2668.283	40*r*	3
2603.306	6	1	2636.268	1	—	2668.501	1	5
2603.731	6	10	2637.976	15	10?	2669.512	1	—
2604.225	1	—	2638.15	—	50*He*	2670.152	2	3
2604.753	3c	10c	2638.591	6	7	2670.524	5	—
2605.013	3	9	2638.877	5c	3	2671.255	4	10
2605.064	1	6	2639.39	1	—	2671.447	2c	—
2606.204	—	5*He*	2639.420	1	2	2671.656	1	2
2608.114	1	1	2639.883	4	5	2671.933	60	200*rv*
2608.690	1	2	2640.825	2	—	2673.332	2	—
2608.836	6	1	2640.918	20	1	2673.566	40	250*rv*
2608.958	5	10	2641.060	6	30	2674.694	4	—
2609.118	1	—	2641.923	4	—	2674.840	1	3*h*
2609.199	—	1	2642.233	40	120*rv*	2675.104	—	2*h*
2609.444	—	2*h*	2642.566	4	5	2675.945	40	80*rv*
2609.622	1	2	2642.87	1	—	2676.124	2	4
2610.268	20	1	2644.29	1	—	2676.952	3	—
2611.318	2c	—	2644.449	2c	—	2677.664	6	15
2612.028	1	—	2644.932	1	3	2678.102	3	6
2612.27	—	5*He*	2645.260	—	30*He*	2678.30	1	—
2612.377	15	1	2646.258	60	150*rv*	2678.663	15	8
2613.854	2	8*h*	2646.636	1	—	2679.015	20	1
2613.927	2	7*h*	2647.500	80*R*	5	2679.880	6	—
2614.306	4	7	2648.034	1	3	2680.061	10	50
2614.444	3	—	2648.223	3	—	2681.066	—	1
2614.759	2	10*h*	2649.515	50*r*	3	2682.129	10	1
2616.219	4	15	2649.714	1	4	2682.469	1	8
2616.476	30	2	2650.001	1	—	2682.524	1	—
2616.683	1	2*h*	2650.322	1	—	2682.849	—	2
2617.046	4	—	2650.568	3	—	2683.216	4	6
2617.102	1	3*h*	2651.122	20	80	2683.713	4	—
2617.427	2	10*h*	2651.810	5	10	2686.388	10	120*h*
2618.178	1c	—	2652.335	2	—	2686.507	1	—
2618.444	2	3*h*	2652.660	—	2	2687.149	30*r*	3
2618.584	1	—	2652.944	8	1	2689.066	2	4
2620.440	25	80	2653.372	10	1	2689.182	2	—
2620.585	8	1	2653.476	6	1	2689.90	—	2*h*
2622.003	7	1	2654.242	2	—	2690.150	1	2
2622.804	4	—	2654.446	60*R*	4	2690.930	3	4
2622.952	8	20	2655.314	1	2	2691.774	40	60*rv*
2623.170	8	4	2655.695	8	1	2692.002	2	10
2623.321	4	7	2655.865	2	8	2692.652	—	3
2623.507	25	2	2656.076	40	80*rv*	2694.316	2	4
2624.330	2	2	2656.984	10	1	2694.753	2	4
2626.401	2	4	2657.613	40*r*	2	2695.038	30	2
2626.472	3	—	2658.027	—	100*He*	2695.601	—	3
2626.636	2	4*h*	2658.711	1	—	2696.052	8	1
2627.055	1c	3c	2658.875	4	5	2697.067	100	300*Rv*
2627.435	60	5	2659.049	4	15	2697.66	—	2
2628.408	3	3	2660.036	5	15	2698.05	1	3*h*
2628.493	20	1	2661.124	3	—	2698.540	3	—
2628.679	—	40*He*	2661.852	8	1	2698.866	50	100*rv*
2629.209	2	3	2662.72	1	4*h*+*H*	2700.153	6	15
2630.354	1	1	2663.552	5	10	2700.312	1	3
2630.983	4	20	2663.705	1	2	2700.555	4	5

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
2700.872	4	10	2744.97	2	30c	2779.71	10	2
2702.197	30	60rv	2745.303	5c	20c	2780.235	40c	150c
2702.521	20	40	2745.725	6	40	2780.600	4	1
2704.250	6	20	2746.10	—	30*Hl*	2780.985	—	4
2704.417	4	5	2746.910	30r	3*d*?	2782.356	20	4
2704.70	—	5	2747.375	—	3	2782.807	—	4
2704.92	—	2	2747.606	—	5	2783.95	1	—
2705.326	1	4	2748.077	—	7	2784.450	—	3
2706.395	10	20	2748.848	30r	3	2785.071	—	6
2707.212	1	3	2749.69	1	4	2785.788	—	2
2707.834	5	20	2749.817	2	5	2786.390	4	1
2709.07	—	2	2750.58	1	15	2788.687	—	3
2709.595	1	3	2752.02	1	6	2789.200	3	1
2711.37	1	5	2752.63	—	3	3789.76	—	8
2712.17	2	—	2752.682	3	—	2790.580	3	10
2713.74	—	2	2753.007	10	—	2790.84	—	4*Hl*
2714.198	5	2	2753.133	6	200c	2791.372	—	5
2715.344	5	50	2753.56	1	5	2791.742	8	80
2715.500	6	—	2753.74	1	3	2792.454	—	1
2715.690	8	—	2754.066	6	1	2793.044	20	80
2715.882	5	40	2754.40	3	—	2793.687	—	3
2716.100	15	1	2754.523	6	40	2793.704	3	—
2716.309	10	15	2755.288	20	2	2793.885	—	7
2716.630	60r	150rv	2755.562	—	5	2793.973	3	—
2717.33	4	10	2755.632	10	—	2795.14	1	15
2717.63	3	8	2755.722	—	3c	2795.868	9	2
2720.024	5	—	2757.256	3	40	2797.215	3	—
2720.259	4	7	2757.50	1	10	2797.693	5c	100c
2720.95	1	6	2758.010	—	1	2798.428	6	1
2721.162	3	6	2758.605	50r	2	2798.903	4	25
2721.632	6	8	2758.78	4	50	2799.180	—	5
2721.987	50r	150rv	2759.160	—	5	2799.354	7	1
2722.310	6	—	2759.968	—	3*h*	2800.315	10	2
2722.69	2	6	2760.441	2	—	2801.551	—	7*c*
2723.660	2	40*h*	2760.91	1	—	2802.066	7	1
2723.986	15	2	2760.990	10	2	2802.73	—	2
2724.95	1	6	2761.737	—	2	2803.54	—	7*H*
2725.33	2	—	2762.32	1	8	2803.810	5	15
2725.68	2	—	2762.49	1	3	2805.83	1	3
2726.080	6	1	2763.025	—	1	2805.98	—	8*h*
2727.43	2	8	2763.380	15	1	2806.913	—	15*h*
2728.076	6	1	2763.59	1	15	2808.050	10	1
2729.372	—	5	2764.561	5	10	2808.74	1	6
2729.524	—	2	2764.996	—	2	2809.172	3	8
2729.829	6	1	2765.271	7	9	2809.666	—	4
2730.324	4	60	2765.431	—	2	2810.810	6	100
2732.25	—	2	2765.918	5	—	2811.436	—	2
2733.258	20r	40rv	2765.952	—	6	2811.625	6	—
2733.464	6	8	2766.182	7	2	2811.70	1	15
2733.74	1	15	2767.218	—	5	2814.53	1	—
2734.027	2	—	2767.754	—	2	2815.399	—	20
2734.36	2	15	27 8.124	20	100rv	2816.430	2	—
2734.733	—	4	2769.290	—	6	2816.678	3	30
2735.948	—	5	2769.561	3	10	2817.31	1	2
2736.521	—	7*c*	2769.765	—	1	2818.199	—	20*c*
2737.083	15	60	2770.907	—	1*h*	2818.617	—	1
2739.239	—	5	2771.398	4	50	2818.74	3	—
2740.185	8	100	2771.65	2	20	2819.215	15	2
2740.971	—	2*c*	2773.197	50	5	2819.893	—	15
2741.146	10	—	2774.052	3	1	2820.38	3	—
2741.71	2	—	2774.488	—	5	2820.803	6	12
2742.604	—	4	2774.935	3	1	2821.924	8	1
2742.79	1	—	2775.758	—	6*h*	2823.34	1	10*d*?
2743.478	—	8	2778.018	—	3	2823.89	1	10
2744.448	—	4	2779.36	8	2	2824.642	3	1

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
2824.785	4	—	2861.76	2	—	2895.39	—	5
2824.863	—	2	2861.98	—	5*H*	2896.00	—	3*H*
2825.180	10	2	2862.49	1	—	2896.24	5*h*	—
2825.86	1	8	2864.324	20	4	2896.998	6	2
2826.044	—	3	2865.609	10	60	2897.32	—	1
2826.47	12	6	2866.672	8	2	2897.345	6	—
2826.97	—	4*h*	2866.86	—	2	2897.605	4	—
2827.071	25	?	2867.28	—	10*h*	2897.803	30	200*R*
2827.116	?	30	2868.524	30	300*R*	2899.230	40c	200*r*
2827.79	—	2	2868.96	2	—	2900.67	—	40*H*
2827.93	—	3	2869.84	—	3	2900.782	1	—
2828.950	3	1	2870.37	—	10*Hl*	2901.692	1	—
2829.367	3	1	2870.654	5	—	2902.329	—	2
2829.750	6	15	2871.06	—	2*h*	2902.60	—	5*H*
2830.56	1	20	2871.238	3	—	2903.16	—	2*H*
2830.85	—	3	2871.65	—	2*h*	2903.650	10	3
2832.78	—	10*h*	2871.91	—	1	2904.13	—	3
2833.312	—	8	2872.51	—	1	2904.87	—	6
2833.51	3	—	2872.81	1	7	2905.56	—	4*H*
2833.648	4	—	2872.93	1*h*	—	2906.422	3	—
2835.106	6	50	2873.68	2*h*	—	2906.80	—	6*H*
2836.079	—	4	2874.564	15	2	2907.206	—	1
2836.245	30	4	2874.98	—	1	2907.53	—	4*H*
2836.45	—	3*h*	2875.386	50c	300c*R*	2908.236	40	200*r*
2839.13	—	5*Hl*	2876.951	30	150	2908.88	5	?
2839.62	—	7*h*	2877.026	50	200c*R*	2908.93	?	120*r*
2839.79	1	6	2877.62	—	10	2908.97	2	?
2840.57	—	1	2877.85	3	10	2909.25	1	—
2840.929	10	2	2878.16	3	—	2910.580	50	400*R*
2841.141	40c	80c	2878.739	8	9	2910.69	2	—
2842.018	6	2	2878.818	3	—	2911.08	2	—
2842.642	30	100*r*	2879.21	—	3*h*	2911.740	20	200*R*
2843.41	—	3*h*	2879.359	4	15	2912.75	1	—
2843.640	3	20	2879.492	8	—	2912.91	—	2
2844.428	3	40	2879.97	1	—	2913.135	2	—
2845.32	—	10*Hl*	2880.712	10	100	2913.72	—	1*h*
2845.52	2	—	2881.17	1*h*	1*h*	2914.41	—	5*h*
2845.798	5	20	2881.31	1*h*	1*h*	2915.059	2	—
2846.280	20	60	2881.84	—	3*h*	2915.18	1	—
2847.23	1	15	2882.471	1	10	2915.412	2	10
2847.89	1	—	2883.168	60c	300c*R*	2916.09	—	8c
2848.02	1	6	2883.60	—	4*h*	2916.40	—	3
2848.296	5	20	2883.626	1	—	2916.500	5	—
2849.04	—	10*Hl*	2883.89	1	—	2917.050	8*d*	100
2849.557	5c	100c	2884.968	12	3	2918.56	—	10
2850.385	—	4	2885.451	2	—	2918.92	1	3
2851.295	—	5	2886.24	—	1	2919.32	—	3
2851.446	20	2	2886.34	1	7	2919.516	1	—
2851.82	—	1	2886.61	—	3	2922.30	—	1*h*
2851.978	15	2	2887.088	2	8	2922.45	—	6
2853.264	3	—	2887.294	6	1	2922.74	—	1*h*
2853.52	1	3	2887.52	1	—	2923.025	8	1
2854.168	12	3*d*?	2887.70	5	10	2924.824	10	2
2855.082	—	3	2888.824	30c	150*r*	2925.15	—	2
2855.54	1	8	2889.898	10	1	2925.360	8	1
2855.82	—	2*H*	2890.174	6	—	2925.77	—	2
2857.294	10	—	2890.350	2	10	2925.89	1*h*	—
2857.363	—	7	2890.56	1	5	2925.93	—	4
2858.42	—	5*Hl*	2891.01	—	3*Hl*	2926.08	—	1
2858.974	10d?	—	2891.41	—	10*Hl*	2926.30	—	2*h*
2859.038	—	20	2893.04	—	8*Hl*	2927.804	100c	600c*R*
2859.46	—	2	2893.47	3*h*	—	2929.13	2*h*	—
2859.962	15	2	2894.43	3c	20c	2929.662	4	1
2861.091	20	100	2894.77	1	—	2930.267	—	60
2861.66	—	3	2894.90	3	—	2930.648	—	7

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
2930.853	—	3	2974.094	25	400*rv*	3007.488	—	4
2931.33	4*Bl*	—	2974.54	5	—	3007.86	2*h*	—
2931.458	10	70	2974.72	—	10	3008.39	—	20*c*
2932.13	—	30	2975.92	—	2	3008.97	—	7
2932.658	1*h*	25	2976.150	1	1	3009.86	—	1*h*
2932.93	1*h*	—	2977.67	4*c*	150*c*	3010.38	1	20
2933.17	—	2	2978.09	—	2*h*	3010.685	1	25
2933.43	—	2	2978.943	4	80	3011.61	—	10*Hl*
2934.980	5	1	2979.34	—	3	3012.546	5	1
2935.282	4	20	2979.50	—	1	3013.27	3*h*	—
2935.75	—	1*h*	2979.875	4	80	3013.62	—	3
2936.36	—	1*h*	2980.717	7	150	3014.438	5	15
2936.50	—	3	2981.28	1	—	3015.02	—	30
2936.67	—	20	2981.636	15	2	3015.24	8	1
2937.327	5	25	2982.100	20*d*	100	3015.82	1	20
2937.707	—	100	2982.90	—	3	3016.19	—	2
2938.067	15	3	2983.13	5	—	3016.258	1	—
2939.67	—	1*h*	2983.57	—	3*H*	3018.31	—	7
2940.88	—	4	2984.077	4	1	3018.853	3*d*	100
2941.536	60*c*	500*cR*	2984.60	1*h*	—	3019.07	1	6
2942.10	1	—	2985.04	3*h*	50	3019.20	—	3
2943.42	—	1*h*	2986.02	1	—	3019.34	2*h*	—
2944.63	5*Bl*?	—	2986.40	—	5*h*	3019.57	—	8
2945.74	6	—	2986.84	3*h*	—	3019.780	3*h*	3
2945.890	12*c*	100*c*	2986.90	—	3	3020.668	20	2
2946.110	10	60	2987.16	—	1	3020.866	—	2
2946.890	10	80	2987.286	15	1	3021.08	—	3
2948.060	2	—	2987.55	—	9	3021.885	—	8
2949.15	1*d*	—	2988.13	1*h*	—	3022.48	—	5
2949.506	—	4	2988.692	6	2	3022.738	8	200
2950.70	2	—	2988.789	6	1	3023.38	2	—
2950.876	80*c*	800*cR*	2989.63	1	—	3024.258	3	10
2952.53	—	1*h*	2989.944	—	40*h*	3024.735	20*c*	250
2952.75	—	1	2990.28	30*c*	200*c*	3025.372	2	40
2952.95	—	1	2991.35	1*h*	—	3026.53	2*h*	—
2953.384	—	2	2991.43	—	6	3026.80	—	2*h*
2954.03	3	5	2991.956	6*c*	80	3027.16	1	—
2954.538	2	20	2992.084	5	—	3027.89	7	2
2954.72	—	4*h*	2993.806	2	20	3028.436	80*c*	300*c*
2955.444	5	2	2993.97	—	20*c*	3028.69	7	—
2956.89	1	20	2994.725	80*c*	300*c*	3028.76	—	10
2958.66	—	1	2995.49	—	4	3029.17	4	1
2958.86	—	1	2996.49	6*h*	2*h*	3029.23	3	—
2959.90	—	2	2996.79	1	7	3029.76	4	60
2959.973	3	1	2997.14	—	1	3029.86	—	20
2960.231	—	3	2997.48	1	8	3030.79	—	2*h*
2961.64	1*h*	15	2997.947	—	1	3032.767	40+Sn	400*rv*
2962.12	2*Bl*	—	2998.220	5	2	3033.396	5	—
2962.288	1	—	2998.312	1	—	3033.47	—	4
2963.205	—	1	2998.56	—	1	3034.95	—	200*cR*
2963.682	5	2	2998.87	—	4*h*	3035.03	3	—
2964.958	—	3	3000.11	7*h*	—	3038.18	—	10*Hl*
2965.11	2*Bl*	—	3000.72	4	—	3039.19	7	2
2965.48	10	3	3001.125	3	50	3039.398	6	10
2965.63	—	6	3001.85	—	150	3039.68	20	—
2965.871	—	8*c*	3002.204	5*d*	40	3039.818	20*c*	150*c*
2967.93	—	3*h*	3003.16	—	2*h*	3040.25	3	—
2968.29	1*d*	10	3003.208	2	—	3040.54	—	4
2969.594	1	—	3003.75	—	3*h*	3040.67	1	—
2970.40	—	10	3004.49	1	—	3041.358	5	2
2970.47	—	10	3004.65	—	10	3041.660	5	1
2972.568	50*c*	200*c*	3005.141	9	2	3041.89	5	—
2973.32	—	6	3005.764	3	60	3041.98	—	10*c*
2972.47	3	—	3006.964	3	1	3042.790	2	15
2973.83	1	—	3007.284	1	—	3043.272	2	10

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
3045.546	5	1	3078.92	—	1*h*	3113.061	4	—
3046.67	2*h*	6*h*	3079.11	—	1*h*	3113.17	1	30
3048.093	20	—	3079.37	—	1*h*	3114.38	2*h*	—
3048.21	2*c*	80*c*	3079.71	—	1*h*	3114.51	1	—
3048.63	1	5	3080.345	15*c*	100	3114.78	—	2
3049.02	—	1*h*	3081.09	—	8	3115.16	—	15
3049.528	2*c*	40*c*	3081.77	2	40	3115.533	2	20
3051.34	1	15	3082.38	—	1*h*	3116.366	15	3
3051.666	6	1	3082.859	10	2	3116.57	1	10*c*
3051.77	1	—	3083.32	—	30*c*	3117.33	—	1*h*
3051.990	8	2	3083.607	1	—	3117.65	1	—
3052.73	5	1	3083.828	2	—	3118.948	1	—
3052.988	6	2	3084.369	2	50	3119.402	6	—
3053.086	10	3	3084.760	—	2	3119.48	—	6*c*
3053.631	3	90	3084.94	4*h*	—	3120.276	3	1
3054.14	3	—	3085.67	1*h*	—	3120.878	5	—
3054.47	1	—	3085.81	—	1	3121.35	3*h*	—
3055.520	6	200	3086.09	—	20*h*	3121.66	2*h*	—
3056.608	9	2	3086.475	2	1	3121.964	5	2
3057.03	—	12	3087.625	4	2	3122.13	1*h*	—
3057.57	—	1*h*	3087.75	1*h*	—	3122.646	15	3
3058.62	—	3	3087.860	6	90	3124.62	—	2*H*
3059.294	1	20	3088.05	9	2	3124.72	1*h*	—
3060.39	5	—	3088.24	1	—	3125.12	3	—
3060.844	—	4	3089.110	—	3	3125.197	2	—
3061.100	8	2	3090.13	2	—	3125.46	—	2*H*
3061.232	10	1	3092.89	1	6	3125.892	1	10
3061.408	—	5	3093.65	1	—	3127.526	30	500
3061.78	2	—	3094.172	200*c*	2,000*cR*	3127.690	2	—
3061.95	1	10	3094.37	5	—	3128.372	5	20
3063.126	3*d*	40	3095.22	2	—	3128.57	—	1*h*
3063.782	9	120	3096.490	10	2	3128.92	2*h*	10
3064.530	40	250*r*	3097.115	3*c*	60*c*	3129.14	2	—
3065.26	20*c*	100*c*	3098.300	3*h*	—	3129.554	4	—
3066.09	5	60	3098.47	2	10	3129.65	3*c*	60
3066.41	3	—	3098.780	2	—	3130.780	150*c*	1,500*cR*
3066.49	—	4	3098.98	2	—	3131.61	2*h*	—
3066.59	3*d*?	—	3099.180	15	100	3132.015	1	10
3067.523	1	20	3100.163	3	—	3132.140	1	4
3068.06	1	20	3100.25	—	50	3132.589	2	—
3068.93	—	5	3100.79	—	20	3132.767	3	60
3069.023	10	5	3100.97	5	—	3132.881	1	—
3069.51	—	5	3101.064	2	—	3133.088	15	3
3069.68	15	100	3101.69	1*h*	—	3133.89	1	—
3070.893	7	80	3101.918	2	20	3134.342	4*c*	40
3071.18	5	40	3103.26	1	4	3134.620	2	—
3071.34	1	—	3103.39	1	—	3134.765	1	—
3071.55	10*c*	90*c*	3104.27	—	8	3134.835	1	—
3071.77	2	—	3104.62	—	2	3135.409	3	25
3072.18	—	10	3104.86	2*h*	—	3135.920	4	30
3072.296	7	—	3105.79	1	—	3136.49	1	—
3072.397	10	—	3106.520	1	10	3136.972	15	3
3072.502	2	60	3106.980	4	80	3137.27	—	3
3073.232	10*d*	50	3108.07	3	—	3137.98	—	2*h*
3074.27	1	5	3108.84	—	1*h*	3138.888	1	—
3074.447	3	—	3109.30	—	1*h*	3140.506	8	100
3075.250	1	10	3109.735	5	1	3140.97	—	4
3075.816	3	—	3110.800	1	20	3142.26	—	100*c*
3076.23	—	1*h*	3111.446	20	3	3142.384	2	—
3076.49	2	—	3111.558	2	—	3142.644	2	—
3076.864	30*d*	200	3111.63	—	5	3142.926	1*h*	—
3077.44	1	10	3111.79	1	—	3143.17	—	3
3077.70	1	—	3112.08	2*h*	—	3143.41	—	4
3077.800	3	—	3112.36	2*h*	—	3143.44	1	—
3078.28	—	1*h*	3112.630	3*d*?	—	3143.77	—	1*h*

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
3144.353	4	60	3175.86	10	150	3203.357	10	150
3144.45	1*h*	—	3176.14	—	4	3204.340	4	—
3145.405	50	500*rv*	3177.41	—	2	3204.66	2*c*	—
3145.920	5	—	3177.766	1	6	3204.973	5*c*	100*c*
3146.863	2	—	3178.17	1	—	3205.975	3	—
3146.92	3	30	3178.23	—	1	3206.11	1	—
3147.57	—	1*h*	3178.632	2	—	3206.350	50	300*rv*
3147.625	2	—	3179.242	1	8	3206.812	5	—
3148.30	—	1	3180.290	50	400	3207.341	5	20
3148.710	6	1	3180.79	2	—	3207.56	—	2
3150.06	—	1	3181.11	1*h*	—	3207.64	1*h*	—
3150.409	5	50	3181.403	8	40	3208.10	1*h*	8
3150.95	1	—	3182.063	5	1	3208.409	1	3
3151.870	30	4	3182.399	4*c*	1*h*	3208.585	2*c*	40*c*
3152.160	5	200	3182.94	—	3*H*	3208.86	3	—
3152.785	4	70	3183.135	1	—	3210.20	—	4
3153.38	—	4*h*	3183.48	1*c*	—	3210.29	15	4
3153.851	1	10	3184.229	6	150	3210.787	2	—
3153.98	10	2	3184.77	1	—	3211.40	—	3*h*
3154.321	2	—	3184.94	—	2	3211.63	—	2*h*
3154.820	4*c*	150*c*	3185.23	—	2	3211.814	2	20
3155.599	3	30	3185.55	2	—	3212.14	1	10
3155.73	1	—	3186.24	—	1*h*	3213.24	1	—
3155.888	2	—	3186.550	15	3	3213.45	1*h*	2*d*?
3156.00	—	3	3187.15	—	1*h*	3213.884	5	—
3157.34	—	2	3187.497	40	4	3213.91	—	3
3157.73	2	—	3188.36	1	4	3214.507	2	—
3158.104	2	10	3188.85	—	4	3215.000	—	5*h*
3158.962	2	—	3189.288	10*c*	180*c*	3215.229	10	1
3159.21	2*h*	—	3189.560	4	—	3215.595	60*c*	300*cr*
3159.332	6	1	3190.44	—	6	3215.959	1	—
3159.855	2	15	3190.490	3	—	3216.193	2	6
3160.59	—	2*h*	3191.096	100*c*	200*c*	3216.43	1	—
3160.60	3	—	3191.427	15	250	3216.47	—	2
3161.194	8	—	3192.16	—	3	3217.00	2*c*	60*c*
3161.244	—	4*c*	3192.39	—	2	3217.288	30	3
3161.49	1	—	3192.73	2	—	3217.865	20	2
3161.56	—	4	3193.003	4*c*	—	3217.797	6	1
3163.149	3	10	3193.47	—	3	3218.98	1*h*	3*h*
3163.403	100*R*	1,000*R*	3194.27	2*c*	30*c*	3219.55	—	2
3164.488	2	—	3194.367	3	—	3219.681	6	—
3164.76	—	1*h*	3194.64	1	—	3219.91	—	1*h*
3165.24	—	1	3194.75	1	—	3220.14	2*h*	—
3166.230	1	—	3194.983	100*r*	700*R*	3220.48	1*h*	4*h*
3166.49	1*h*	—	3195.22	2	—	3220.927	15	3
3166.59	2*h*	—	3195.96	—	2	3221.126	15	3
3167.32	—	3*h*	3196.17	—	3	3221.436	2	—
3167.96	—	1	3196.18	5	—	3221.53	1	—
3168.141	2	—	3196.71	1*h*	—	3221.655	—	8*c*
3168.599	8	1	3197.28	—	20*h*	3222.065	6	50
3170.163	4	1	3197.94	1*h*	—	3222.754	7	1
3171.168	6	2	3198.182	3	—	3222.958	6	1
3171.425	10*c*	1	3198.227	2	20	3223.004	3	—
3171.80	—	50*h*	3199.88	—	4*h*	3223.332	10	100
3172.25	—	5*h*	3200.102	3*c*	—	3223.448	1	—
3172.304	4	—	3200.24	—	3*h*	3223.751	3*c*	—
3172.511	12	2	3200.537	15	2	3223.903	2*c*	—
3173.205	10	150	3200.69	—	1	3224.434	8	1
3173.677	4	—	3200.78	—	1	3225.009	2	—
			3201.21	—	1*h*	3225.194	9	—
3174.44	—	6*h*	3201.498	4	—	3225.478	150*c*	500*cR*
3174.73	—	1	3201.66	—	3	3227.209	2	—
3175.40	—	1	3202.416	1	—	3227.49	2*h*	—
3175.68	3	—	3202.73	1	—	3227.69	—	6
3175.76	3	50	3203.148	—	10*h*	3227.711	4	—

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
3228.47	—	6	3253.339	4*d*	—	3279.248	7*c*	20*c*
3228.953	1	6	3253.45	1*h*	—	3279.43	1	4
3229.19	4	1	3254.070	60	200*r*	3279.826	8	—
3229.455	1	—	3254.455	2	—	3279.979	3	80*h*
3229.567	20	100	3254.71	2	—	3280.96	—	1
3230.243	3	40	3254.888	3	25	3281.28	—	2*h*
3230.53	1	—	3255.27	1	5*h*	3281.62	—	2*h*
3230.794	2	—	3255.590	2	—	3282.608	1	—
3231.336	1	—	3255.80	—	1*h*	3282.77	—	1
3232.661	2*h*	—	3256.03	1	—	3282.990	5	—
3232.79	—	5*h*	3256.15	—	5*H*	3283.463	25	400
3232.891	2	—	3256.75	—	2	3284.04	1	—
3232.984	3	—	3257.004	3*c*	1	3284.81	1	—
3233.92	—	2*h*	3257.17	1	—	3284.890	2*c*	—
3234.182	—	2	3257.65	1*h*	—	3285.381	3	—
3234.26	1	1	3258.39	—	4*H*	3285.488	1	—
3234.65	1	—	3258.85	1	—	3285.668	60	?
3235.066	1	—	3259.140	6	1	3285.70	?	30*c*
3235.182	2	—	3259.523	—	1	3286.340	1	40
3235.78	—	2*h*	3260.139	20	2	3286.81	—	5
3236.078	2	—	3260.564	30*c*	350*c*	3287.592	50	4
3236.403	80	300*r*	3261.036	2	—	3287.72	1*h*	—
3236.704	2	—	3261.702	3	60	3287.75	—	3
3236.810	1	—	3261.88	—	3	3287.923	40	5
3237.187	8	—	3262.56	—	6	3288.19	3*h*	—
3237.690	4	60	3263.365	10	300	3289.460	8	1
3238.020	10*c*	80*c*	3263.793	3	—	3289.551	2	10
3238.394	3	—	3264.261	2	—	3289.82	—	1
3238.975	2	—	3264.597	40	5	3290.007	15	2
3239.23	—	2*h*	3265.313	5	1	3290.30	1*h*	—
3240.582	3	—	3265.53	—	1*h*	3290.55	—	3
3241.111	1	—	3266.008	6*c*	—	3291.055	10*c*	30
3241.29	—	3	3266.11	—	80*c*	3291.921	10	—
3241.818	3	40	3266.413	9	—	3292.020	15	200
3242.423	1	8	3267.052	15	4	3292.365	2*c*	10*c*
3242.532	5	40	3267.684	3	30	3292.806	2	—
3242.67	1	—	3268.946	2	—	3294.250	1	—
3242.928	3	—	3269.125	3*c*	20	3294.367	4	150
3243.322	4	—	3269.493	3*c*	—	3295.506	1	20
3243.725	1	—	3269.87	—	2*H*	3296.025	80	10
3243.83	—	6	3270.465	25	4	3296.478	10	1
3244.20	1*h*	—	3270.761	20	4	3297.055	7	20
3244.515	2	30	3270.93	—	2*h*	3297.286	8*d*	—
3244.684	2	—	3271.55	—	5*H*	3297.673	5	15
3244.784	2	—	3271.982	10	3	3298.410	12	2
3245.07	—	5	3272.074	25	5	3298.977	4	1
3245.59	—	2	3272.224	5	100	3299.29	—	1*h*
3246.69	—	6	3272.350	1	10	3299.57	—	50
3246.76	—	3	3273.139	3	—	3299.608	30	—
3246.782	15	—	3273.511	5	20	3300.33	1	6*h*
3247.478	12*c*	150*c*	3273.758	1	—	3300.81	—	1*h*
3247.575	1Cu?	—	3273.888	3	15	3301.498	2	40
3247.645	3	—	3274.355	2	—	3301.96	—	3
3248.18	1*h*	—	3274.455	—	1	3302.183	15*c*	2
3248.941	10	80	3274.796	3	30	3302.48	3	—
3249.517	50	5	3275.13	2	—	3302.619	1	10
3250.27	1*h*	40	3275.960	5	1	3302.80	1*h*	—
3250.448	1	—	3276.304	2	—	3303.07	3*c*	—
3250.897	1	—	3276.43	—	6	3303.323	3	50
3251.260	3	50	3276.567	4	—	3304.71	1	40
3251.490	9	—	3277.30	—	3	3304.836	20	5
3251.630	30	3	3277.676	50	5	3305.608	3	70
3252.430	1	10	3277.77	—	4	3306.29	1	—
3252.771	7*c*	—	3278.307	1	—	3306.778	3	1
3253.16	—	1	3278.599	4	—	3308.050	40	4

TABLE 2.—*Arc and spark spectra of columbium (Z=41)*—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
3308.710	2	—	3333.970	10	2	3357.156	—	2
3308.78	1	—	3334.529	—	8c	3357.899	4d	1
3309.26	—	5	3334.82	2	8	3358.422	250r	40
3309.617	2	1	3335.244	2c	10c	3358.77	4	1
3309.805	6	2	3335.420	20c	3c	3359.874	7	1
3310.097	5	2	3335.669	—	5c	3360.904	6	100
3310.37	2	—	3336.04	1	—	3361.35	2	—
3310.469	25	3	3336.321	15	2	3361.86	2d	—
3310.67	—	20h	3337.20	—	2h	3362.17	—	20h
3311.341	15	4	3337.87	4	—	3362.866	10	2
3311.75	2c	—	3338.38	—	3	3363.34	—	2h
3311.95	1c	—	3339.158	12c	2c	3363.750	15d	2
3312.607	120	15	3339.268	8	1	3365.594	15	100
3313.08	—	3h	3339.40	—	1h	3365.883	6	?
3313.41	—	4	3339.783	6	1	3365.94	2	100
3313.64	—	2	3340.18	—	4h	3366.956	50	10
3314.10	1	—	3340.45	1	60d	3367.085	8	2
3314.587	2	—	3341.612	10	150	3367.382	25	4
3315.226	40	5	3341.982	200r	20	3367.867	—	2h
3315.979	1	—	3342.369	4	1	3368.426	10d	2
3316.61	1	15	3342.48	2	—	3369.081	20c	?
3317.04	1	1h	3342.912	4	—	3369.155	5	100
3317.363	2h	2h	3343.28	—	5	3369.719	4	—
3318.29	1	5	3343.712	150r	15	3369.840	20d	2
3318.461	2	—	3343.90	3	—	3370.154	—	50
3318.982	50	5	3343.967	8	80	3370.609	4	30
3319.22	—	10c	3344.25	1	8h	3371.331	40	6
3319.265	40	?	3344.41	1	—	3372.101	10	2
3319.590	15	100	3344.50	1	—	3372.164	6	—
3320.124	—	1	3345.16	—	2h	3372.565	8	120
3320.56	—	2	3345.178	4	—	3373.71	1	—
3320.803	5	80	3345.40	2c	—	3374.029	5	—
3321.53	4	—	3345.949	5	—	3374.087	—	20h
3321.81	—	1h	3346.09	1	—	3374.252	6	50
3321.846	2c	—	3346.286	—	20c	3374.928	60	10
3322.00	2	—	3346.760	10	30	3376.341	12	3
3322.245	6	1	3346.935	25	5	3376.59	1	—
3322.68	4c	—	3347.558	6	1	3376.732	15	3
3322.816	8	2	3348.082	4	—	3377.09	—	2h
3323.22	—	3h	3348.28	2h	20	3377.375	—	9c
3323.900	3	30	3348.787	1	15	3377.743	6	1
3324.555	4	30	3349.068	200r	10	3378.162	1	1h
3324.661	2	50	3349.351	3	100	3379.300	4	60
3325.21	—	4h	3349.524	40c	2c	3380.055	20	3
3325.436	—	20h	3350.048	4	—	3380.420	40	4
3325.744	6	—	3350.41	—	3h	3380.490	7	—
3325.946	1	—	3350.689	7c	1	3380.862	20	?
3326.077	1	—	3351.33	2h	—	3380.934	3	150
3326.54	—	7	3351.511	1	—	3382.44	2c	40h
3326.621	50	6	3351.819	3c	—	3382.91	2	2
3326.745	4	—	3351.87	—	3h	3383.302	—	10c
3327.246	—	3h	3352.282	12	2	3383.802	15	3
3327.415	1h	—	3352.592	15	2	3384.50	1h	—
3327.923	10	2	3352.828	—	5h	3384.662	20	4
3328.163	6	1	3352.868	10c	—	3385.192	4	1
3328.398	6	1h	3353.352	7d	1	3385.665	12	2
3328.844	1	—	3353.509	15	10	3385.815	10	2
3329.16	—	20h	3353.675	6d	—	3386.243	20	250
3329.364	40	3	3354.743	80	15	3386.995	20	3
3329.622	10	2	3355.423	12	2	3387.579	10	3
3331.67	1h	—	3355.67	—	1h	3387.754	15	3
3331.895	10	2	3355.92	—	3h	3387.928	—	2h
3332.164	25	4	3356.465	8c	—	3388.537	—	1h
3332.704	15	3	3356.76	1	—	3388.939	4	30
3333.516	1	—	3357.043	25	4	3389.046	1	—

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
3389.73	1	—	3420.11	7*d*	1	3452.373	20*c*	?
3390.08	1*c*	—	3420.287	4	—	3452.652	15*c*	2*c*
3390.413	7*c*	1	3420.633	10	80	3453.08	3*c*	—
3390.623	25*c*	4*c*	3421.161	5*c*	20*c*	3453.425	2	—
3391.332	10	2	3421.318	—	3	3453.96	—	5*c*
3391.429	7	1	3422.06	—	1*h*	3454.708	4	60
3391.594	2	9	3422.119	1	—	3454.910	4	80
3391.732	4	—	3422.35	1	—	3456.543	12	3
3392.345	100	10	3422.77	2	5	3456.993	5*h*	?
3392.475	—	4*h*	3422.85	1	10	3457.04	?	4*h*
3393.679	2	—	3423.23	2*h*	—	3457.205	2	—
3393.810	2	10	3423.643	—	5*c*	3457.801	20	3
3394.090	12	1	3423.765	30	4	3458.728	?	10
3394.217	6	1	3424.30	—	1*h*	3458.740	7	?
3394.978	8	60	3425.432	30*d*	300*c*	3458.87	5	—
3395.455	4	—	3425.855	30*c*	2	3458.951	12	2
3395.72	3	15	3426.562	25*d*	250*c*	3459.56	—	15
3395.928	40	3	3426.730	4*c*	—	3459.702	25	5
3396.365	6	50*h*	3427.454	50	7	3460.66	5	—
3397.319	—	10*h*	3427.74	—	1*h*	3461.54	—	4*c*
3397.43	1	—	3428.369	7	1	3461.61	5	—
3397.516	—	5*h*	3428.795	15*c*	3*c*	3462.647	15	3
3397.836	2	—	3429.059	20	5	3463.033	10	3
3398.254	15	6	3430.428	—	2*h*	3463.685	8	2
3399.399	25	4	3430.912	—	2*h*	3463.813	25*c*	10*c*
3399.714	15	30	3431.064	8*d*	—	3465.610	3	—
3399.967	10	1	3431.18	—	4*h*	3465.860	30	3
3401.231	8	10	3431.955	10	1	3466.231	2	—
3402.02	2	20	3432.420	15*c*	1*c*	3467.474	15	3
3402.40	1	—	3432.708	10	400	3468.127	—	15*c*
3402.81	—	2*h*	3433.099	12	1	3468.17	1	—
3403.013	15*c*	2*c*	3433.18	6	—	3468.374	1	3
3403.49	—	3*h*	3433.747	—	5*h*	3468.549	8	2
3403.755	10	2	3433.952	—	3	3468.942	3	—
3404.512	4	—	3434.118	4	—	3469.135	7	1
3404.989	1	—	3434.588	—	2*h*	3469.244	3	—
3405.418	60	10	3435.02	—	2*h*	3469.442	15	3
3406.140	40	6	3435.04	3*h*	—	3470.27	5*d*	50
3406.616	10	2	3435.583	—	2*h*	3471.036	5	—
3406.947	—	10*h*	3435.899	—	2*h*	3471.198	10	2
3407.32	1	10	3436.834	4	20	3471.28	2*c*	—
3407.980	10	4	3436.964	15	60	3471.526	9	1
3408.380	50	5	3438.41	1	80	3472.776	5	1
3408.53	—	3*h*	3439.342	8	2	3473.020	30*c*	5*c*
3408.678	20	100	3439.702	4	—	3473.125	7	2
3409.191	20	100	3439.925	10	60	3473.362	5*c*	—
3409.915	15	2	3440.589	30	200	3474.004	4	20
3410.66	1	1*h*	3441.64	5*c*	10*c*	3474.68	5*c*	25*c*
3410.96	—	1*h*	3442.655	12	2	3474.99	1	—
3411.50	—	1*h*	3442.800	10	1	3475.590	15	3
3412.480	1*h*	10*h*	3443.737	1	20	3475.996	10*c*	2
3412.934	25	150	3444.281	4	60	3476.28	—	6
3413.209	2	20	3445.67	40*c*	8*c*	3476.655	1	—
3413.51	10*d*	1	3446.382	1	—	3477.26	1	—
3414.070	15	3	3446.747	3	—	3477.92	1	—
3415.22	1	2*h*	3446.928	1	5	3478.010	8	1
3415.603	4	—	3447.843	1	—	3478.335	4	1
3415.984	30*c*	5*c*	3448.221	4	40	3478.690	40	4
3416.32	—	1*h*	3448.674	2	20	3478.79	7	100
3417.17	—	5*h*	3448.76	1	—	3479.567	20	150
3417.272	5*d*	—	3450.766	6	60	3480.213	4	80
3417.80	—	2	3451.12	3*c*	—	3481.054	15	3
3417.867	15	5	3451.640	1	20	3481.265	9	2
3418.31	1*h*	2*h*	3452.19	—	3*h*	3481.82	2	—
3419.148	1	—	3452.350	?	40	3482.19	1	—

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
3482.52	1	5*h*	3514.911	3*c*	—	3544.346	1	15*h*
3482.953	2	100	3515.421	20*c*	200*c*	3544.656	50	8
3483.23	1	—	3516.198	10	2	3545.381	6*c*	1*c*
3483.754	3	—	3516.342	3	—	3546.031	12	2
3484.054	15	80	3516.863	15	3	3546.160	5	1
3484.625	5	10	3517.111	10	3	3546.489	8	1
3485.102	8	1	3517.670	6	150	3546.910	2	—
3485.935	12	3	3517.77	12	—	3547.016	1	—
3486.724	7*c*	2	3517.84	5	—	3547.426	3	—
3487.52	2	—	3518.180	8	1	3548.08	—	4*h*
3487.814	1	—	3519.337	6	2	3548.130	15	2
3487.968	1	—	3519.66	—	5*h*	3549.263	12	2
3488.50	1	—	3520.055	40	5	3549.96	1	—
3488.742	2	—	3520.717	12	2	3550.237	10	1
3488.81	3	80	3521.14	1	20*h*	3550.448	50	7
3489.093	10	90	3521.599	—	5*h*	3550.624	6	1
3490.12	1	—	3522.368	—	10*h*	3551.102	8	4
3490.418	—	10	3522.630	2	—	3551.37	1	—
3491.024	50*d*	7*d*	3522.787	6	2	3552.000	5	1
3491.477	15	3	3523.156	12	2	3552.227	6	—
3491.896	1	20	3524.93	8	2	3552.815	1	—
3492.56	3	—	3525.219	30*c*	5*c*	3553.613	10*c*	—
3493.476	5	1	3525.88	8	—	3554.14	1	6*h*
3494.57	3	1	3525.986	—	50*h*	3554.524	60	6
3495.18	1	—	3526.209	2	—	3554.666	80	8
3495.473	3*d*	1	3527.024	—	8*c*	3555.63	1	—
3495.71	1	—	3527.108	10	1	3556.022	10	2
3496.027	20*c*	30*c*	3527.280	6*c*	—	3557.023	2	—
3496.284	2*d*	—	3527.959	10	2	3557.684	1	—
3496.879	1	—	3528.09	—	5	3558.015	9	2
3497.646	5	2	3528.315	10*c*	—	3559.128	12	2
3497.815	30	5	3528.474	4	30	3559.470	1	—
3498.358	3*c*	—	3528.890	2	20	3559.592	4	60
3498.441	5	1	3529.394	8*c*	1	3559.893	—	6*h*
3498.631	60*c*	10*c*	3530.093	10	2	3559.92	1	—
3498.783	7*c*	—	3530.824	7	2	3560.357	7	—
3499.93	—	30*c*	3531.305	1	—	3560.47	1	5
3499.957	8*c*	—	3532.521	5*c*	—	3561.142	12	2
3500.109	8	1	3533.667	40	4	3561.697	6	1
3500.74	—	10*h*	3534.05	?	10*h*	3561.88	—	4
3500.96	1	—	3534.114	20*c*	?	3562.649	6*c*	1
3501.32	1	15	3534.215	3	50	3562.846	3	1
3503.206	20	3	3534.428	7	—	3563.232	6	1
3504.59	1	—	3534.85	1*h*	—	3563.501	100	7
3505.629	2	—	3535.304	400*c*	20*c*	3563.624	80	5
3505.812	12	2	3535.845	1	—	3564.028	6*c*	—
3505.992	—	5*c*	3536.212	4*c*	1	3564.075	—	15*h*
3506.025	7	—	3537.106	1	—	3565.052	10*c*	—
3506.991	10	2	3537.157	1	—	3565.23	—	1
3507.960	80	7	3537.475	150	6	3565.68	—	3*h*
3508.21	1*h*	—	3537.625	8	40	3565.855	6	—
3508.529	8*c*	1	3538.076	2	—	3566.10	—	40*h*
3509.872	1	—	3538.58	2	—	3566.33	2	—
3510.262	20*c*	400	3538.62	—	2*h*	3567.099	5*c*	—
3510.41	1*d*	—	3539.11	—	6*h*	3568.001	4	40*h*
3511.13	10*c*	1	3539.650	15*d*	3	3568.50	?	30
3511.189	20*c*	2	3540.961	30	200	3568.515	10*c*	?
3511.614	1	—	3541.247	6*c*	50	3568.727	20	3
3512.309	5	1	3541.898	20*c*	3*c*	3569.464	40	6
3512.749	6	1	3542.560	10	2	3569.692	5	1
3513.24	1	—	3542.983	15	4	3569.854	7*c*	1
3513.545	2	—	3543.55	1	—	3571.124	3	—
3513.673	3	—	3543.745	5	1	3571.485	6*c*	—
3513.721	2	—	3543.936	12	2	3572.10	1	—
3514.02	—	20*c*	3544.031	50	6	3573.096	5	1

TABLE 2.—*Arc and spark spectra of columbium* (Z=41)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
3573.42	2c	—	3607.01	3	15	3637.830	35c	4c
3574.202	1	10	3607.33	7	3c	3637.86	—	15h
3574.312	3	—	3608.013	10d	2	3638.673	2c	—
3575.139	20c	3	3608.316	9	2	3638.792	20c	2
3575.55	1	—	3609.24	1	—	3639.058	4	30
3575.850	200	20	3609.362	1	6	3639.335	40c	6c
3577.238	8c	2	3610.002	8c	1	3640.638	30	4
3577.721	40	6	3610.765	7	2	3641.293	1	15
3578.23	4	1	3611.285	7c	1	3641.382	2	20
3578.317	3	—	3611.39	—	3	3641.514	3	—
3578.38	—	2	3612.165	1	—	3641.571	3	—
3578.586	4c	1	3612.657	9	2	3642.587	2	—
3579.186	3	—	3613.013	9	2	3643.343	15	3
3580.277	400r	50	3613.25	—	4	3643.526	5	1
3580.788	9	2	3613.45	7c	1	3643.725	25c	4c
3580.98	—	4h	3614.88	—	3h	3644.17	1h	—
3582.062	10c	2c	3615.500	30c	8c	3644.70	1h	—
3582.369	25	4	3615.971	4	1	3644.935	20	3
3583.095	2	—	3616.216	10	2	3645.360	9	1
3584.33	—	3h	3616.497	6	1	3645.94	1	6h
3584.357	1	—	3617.714	15	2	3646.118	4	—
3584.47	4	1	3618.043	1	—	3647.306	20c	4c
3584.972	100	10	3618.441	15	2	3647.724	7	1
3586.695	4	—	3618.907	15	4	3647.867	7	—
3586.75	—	50h	3619.207	10	—	3648.063	3d	1
3586.869	6	—	3619.514	30	200	3648.760	—	3h
3587.400	9d	2	3619.729	15c	100c	3648.84	1	—
3587.942	2	—	3620.57	—	6h	3649.854	60	5
3588.02	—	10h	3621.030	40	4	3650.168	4	—
3589.106	100	10	3621.92	1	—	3650.241	1	—
3589.356	100c	10c	3622.389	2	—			
3589.960	8	2	3622.49	—	3h	3650.31	2	—
3590.712	10c	3c	3622.621	4	—	3650.516	5	1
3590.904	10	2	3622.90	—	3h	3650.803	40c	4c
3591.197	6	40	3623.14	6c	—	3651.182	30	200
3591.52	2	—	3623.43	1	—	3651.304	6	—
3591.790	9	2	3624.357	7	2	3652.25	—	8h
3592.360	3	1	3625.169	15	3	3652.275	2	—
3593.45	1	—	3625.717	15	4	3653.276	4	1
3593.543	2	—	3627.870	8	1	3653.616	4	—
3593.966	80	9	3628.180	2	40	3654.232	1	—
3594.53	2	—	3628.921	4	—	3654.270	—	4
3596.361	2	—	3629.47	1	30	3654.430	10c	2
3597.260	15c	3c	3630.623	15	3	3655.975	20	4
3597.514	8	2	3630.700	5	1	3656.265	1	—
3598.343	12d	2c	3631.338	4	1	3656.495	5h	1
3599.279	20c	4c	3631.53	1h	—	3657.110	15	4
3599.635	20	5	3631.785	4	—	3657.254	4	1
3600.16	1	—	3633.006	15	2	3657.693	4	1
3600.678	3	1	3633.12	2	4	3657.897	8	2
3602.219	2	1	3633.318	6	100	3658.604	4	—
3602.561	60	10	3633.717	20	2	3658.648	4	—
3602.68	3	—	3633.894	—	5h	3657.750	7d	1h
3602.74	2	—	3634.03	1h	1h	3659.602	20c	300
3602.876	6	1	3634.452	15	—	3660.364	100	10
3603.435	10	2	3634.489	—	40	3660.498	2	—
3603.962	8	2	3634.604	5	—	3660.74	2	—
3604.072	8c	1c	3635.328	15	3	3661.680	10c	4
3604.643	7c	—	3635.468	6c	—	3662 051	15	3
3604.66	—	8h	3635.852	12c	2c			
3604.96	—	1	3636.457	2	—	3662.73	—	4
3606.272	8c	—	3636.64	2	1	3662.927	5	1
3606.35	—	2h	3636.959	30c	3c	3663.167	8c	—
3606.492	10d	2	3637.306	4	—	3663.313	2	—
3606.806	8	1	3637.545	20	3	3663.432	6	1

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
3663.751	—	60*h*	3692.518	1*h*	—	3722.548	—	40*h*
3664.467	—	2	3693.365	20	3	3722.942	20*c*	2*c*
3664.692	80	10	3693.667	4	—	3723.10	6	—
3664.822	7	2	3693.767	5	1	3723.44	1	30*h*
3665.157	10*d*	2	3694.669	20	3	3723.742	—	3*h*
3665.54	2	—	3694.792	—	10	3724.47	4	1
3666.534	15	4	3694.91	1	—	3724.96	4	1
3667.001	12*c*	3*c*	3695.38	1*h*	—	3725.195	20*c*	—
3667.665	10*c*	2	3695.90	8	100	3725.25	2	6
3667.760	8	2	3696.68	3	10*h*	3725.648	4*c*	1
3668.435	3	1	3697.024	6*d*	1	3726.235	250	20
3668.626	20	4	3697.155	1	—	3726.50	1	2
3669.009	40	6	3697.397	20	4	3726.56	2	4
3669.347	8*h*	2*h*	3697.850	200	20	3726.64	3	6
3669.736	20*d*	3	3698.79	—	2	3727.229	20	3
3670.05	1	20*h*	3698.893	3	—	3728.707	2	—
3671.372	12	2	3699.078	5	1	3729.613	7*d*	1
3671.735	6	1	3699.582	5	1	3730.853	1	—
3672.443	9	2	3699.928	30*c*	4*c*	3731.377	1	—
3672.580	8	2	3701.44	1	3	3731.534	8*c*	2*c*
3672.726	4	1	3701.713	—	3	3732.034	15	4
3673.227	8*c*	2*c*	3701.99	4	1	3732.702	5*c*	1
3674.469	4	1	3703.167	30*c*	6*c*	3733.344	15*d*	4
3674.691	15	2	3703.916	20*c*	5*c*	3733.622	15	2
3674.787	40*c*	6*c*	3704.137	40*c*	8*c*	3734.733	6	1
3675.17	5	1	3704.628	3	1	3735.931	2	—
3675.304	10	2	3705.602	10*c*	—	3736.32	4*h*	—
3676.307	20	—	3707.088	7*c*	—	3736.49	—	3*h*
3676.335	—	15	3707.803	10	—	3738.427	30	5
3677.084	20	3	3707.96	—	60*c*	3738.51	4	—
3677.771	15	2	3708.38	4*c*	—	3739.28	1	—
3677.905	4	—	3708.900	8	1	3739.80	300*r*	30
3678.063	2	40	3709.139	2	—	3740.537	8*c*	—
3678.70	10*c*	1	3709.29	—	100*c*	3740.726	10	200
3679.04	1	—	3709.422	25	3	3740.845	40	4
3679.61	—	10*h*	3709.736	6	—	3741.292	4	10
3680.857	5	1	3709.802	3	—	3741.553	1	—
3681.360	3	—	3709.947	2	—	3741.776	30*c*	4*c*
3681.57	—	2	3710.448	20*c*	4*c*	3741.99	2	—
3681.680	5	?	3711.343	60	7	3742.09	3	—
3681.690	—	6	3711.782	12	2	3742.393	200*r*	20
3682.13	1	—	3712.554	6	1	3743.18	1	—
3682.89	1	1	3713.018	300*r*	20	3744.007	40*c*	8*c*
3682.96	1	2	3713.356	—	25*h*	3744.279	4	1
3683.03	2	3	3713.72	2	50*h*	3745.476	6	1
3683.10	2	4	3713.819	20	2	3746.04	1	—
3683.973	5*c*	1	3714.59	—	2*h*	3746.904	25	5
3684.18	1	—	3714.852	5*c*	1	3747.841	3	—
3684.253	5	1	3715.196	4*c*	—	3748.00	1	3
3684.931	1	4	3715.974	6	1	3748.41	1	—
3685.128	10*c*	1*c*	3716.214	30*c*	2*c*	3748.557	20	5
3686.068	3	1	3717.01	40*c*	?	3749.248	1	—
3686.557	10	2	3717.06	20?	300	3749.415	1	—
3686.665	3	1	3717.31	1	—	3750.223	6	2
3687.440	8	1	3717.538	30	3	3750.517	5	1
3687.968	20*c*	200*c*	3718.524	6	1	3750.637	10	2
3688.187	10	50*hl*	3719.52	1*h*	—	3751.285	1	20
3688.698	15	2	3719.63	—	30*c*	3752.01	1	—
3688.81	4	—	3720.456	10	100	3752.08	1	—
3689.038	15	2	3721.277	6	1	3752.297	5	—
3689.27	—	3	3721.40	—	1	3752.723	9	1
3689.409	5	1	3721.517	10	1	3752.93	—	1
3691.174	4	30	3721.637	4	—	3753.171	40	4
3691.37	3	—	3722.170	4	—	3753.47	1	—
3692.178	—	5	3722.328	15	2	3754.228	2	—

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
3754.86	1*d*	—	3784.537	2	—	3816.342	15	3
3755.289	10	2	3784.73	1	—	3816.645	3*c*	—
3755.636	6*c*	1*c*	3784.88	3	5	3818.190	6*c*	—
3755.764	20	6	3785.384	3	1	3818.862	20	200
3755.940	4*c*	—	3786.10	6*c*	1	3819.148	40	5
3756.251	7	2	3786.227	10	2	3820.744	1	—
3757.02	4*c*	—	3787.064	150	20*c*	3821.201	12*c*	2*c*
3757.466	—	3*h*	3787.280	8*c*	1	3821.72	1	2
3757.60	—	1*h*	3787.480	15	2	3822.325	2	—
3757.62	2	—	3788.188	4	1	3822.956	4	1
						3823.135	6	1
3759.556	200*r*	20	3788.69	3*c*	—			
3760.646	12	2	3789.502	20	3	3823.255	3	—
3760.76	1	15*h*	3790.138	200*r*	30*c*	3824.00	—	4*h*
3761.130	30*c*	3*c*	3791.209	300*r*	40*c*	3824.17	—	5*h*
3761.32	—	2*h*	3791.446	8	2	3824.882	100	10
						3825.410	5	1
3762.064	2*c*	2*h*	3791.999	7*c*	2*c*			
3762.445	10*h*	2*h*	3792.79	—	30*h*	3826.574	3	—
3762.99	—	3*h*	3793.727	5*c*	1	3827.015	12	2
3763.13	1*h*	8*h*	3794.476	15	3	3827.43	1	—
3763.492	40	5	3795.182	2	—	3828.045	4	—
						3828.242	6	40
3763.730	4	1	3795.527	?	6*h*			
3764.115	25	4	3795.543	30*h*	?	3829.221	—	6*h*
3764.536	4	—	3796.440	20*c*	6*c*	3829.659	3	—
3764.641	—	5*h*	3796.599	12	3	3830.006	10	1
3765.074	40*c*	6*c*	3796.850	15*c*	6*c*	3830.601	—	20*c*
						3830.64	1*h*	—
3765.794	6	1	3798.127	300*r*	40*c*			
3766.140	30*c*	6*c*	3798.76	1	—	3830.820	1	—
3766.52	1	—	3799.486	5	1	3831.074	2	—
3766.62	1	—	3800.197	5	1	3831.198	6*d*	—
3767.421	5	1	3800.941	20	5*h*	3831.840	15	200
						3832.134	1	—
3769.145	20	3	3801.146	5	80			
3769.624	4	1	3801.302	20	3	3832.625	2	—
3769.983	15	2	3801.994	2*c*	—	3833.257	10*c*	2
3770.332	4	—	3802.19	1	—	3833.769	2	—
3770.66	—	30*h*	3802.480	4	—	3833.940	6	1
						3834.575	2	1
3770.71	12*c*	—	3802.555	5	—			
3770.870	20	3	3802.636	6	1	3835.176	40	6
3771.14	2	—	3802.928	400*r*	40*c*	3835.406	2	—
3771.79	3?	—	3803.65	1	—	3835.65	1	—
3771.848	40	6	3803.879	100	10	3836.260	3*c*	—
						3836.452	20	3
3772.721	3	—	3804.01	4	10			
3773.154	10	2	3804.204	10*c*	1	3836.738	5*c*	1
3773.22	2	—	3804.733	40	100	3837.077	12*c*	2*c*
3773.628	6	1	3805.23	—	1	3837.714	1	—
3774.39	4	1	3806.196	20	4	3837.995	4	—
						3838.072	2	—
3774.44	8	2	3806.631	10	2			
3774.98	1	—	3807.485	1	—	3838.42	2	—
3775.16	2	—	3807.95	2*c*	—	3840.16	1*h*	1*h*
3775.449	20	4	3808.10	—	4*h*	3841.666	—	10
3776.157	6*c*	1	3808.48	1	—	3841.820	30	4
						3842.709	20	3
3776.605	7	1	3808.70	1	1*h*			
3777.277	8	1	3808.95	1	—	3843.397	—	8*h*
3777.670	15*c*	3	3809.27	—	2*h*	3843.453	4	—
3778.50	2	—	3810.50	80*c*	30*c*	3843.927	10*c*	2*c*
3778.675	5	—	3810.88	3*c*	—	3844.090	12	3
						3845.079	2*c*	—
3779.03	1	—	3811.035	50	6			
3779.22	4	—	3811.41	—	5*h*	3845.29	—	2*h*
3779.57	1	20*h*	3811.44	1	—	3845.307	4*c*	—
3781.017	80	5	3813.01	5*c*	—	3845.900	40	6
3781.379	10	200	3813.416	1	—	3846.00	1	—
						3846.658	1	—
3781.90	1	—	3813.470	5	—			
3782.40	5*c*	—	3814.188	4	1	3848.46	1	—
3782.71	1	—	3814.71	2	—	3848.66	1	—
3783.53	1	—	3814.889	1	—	3849.744	6*c*	1
3783.844	20*c*	5*c*	3815.507	60*c*	10*c*	3850.056	—	3*h*
						3852.41	1	—

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
3852.63	1	6*h*	3878.965	20	3	3909.600	15	3
3853.096	4	1	3879.350	15*c*	200*c*	3909.665	4	1
3853.388	20	5	3879.644	7	—	3910.156	4	1
3853.59	4*c*	1	3880.122	1	—	3911.036	—	2*h*
3854.127	6	2	3880.40	1	—	3911.327	1	—
3854.698	9	2	3880.543	2	—	3911.587	1	—
3855.07	—	4*h*	3880.90	1	—	3912.084	2	—
3855.146	12	4	3881.407	1	—	3912.48	1*d*	—
3855.456	15	—	3881.541	1	—	3913.011	15	3
3855.500	—	50*h*	3881.85	—	4*H*	3913.15	8*c*	1*c*
3855.711	1	—	3882.660	8	2	3914.362	4	1
3856.683	6	?	3882.894	6	1	3914.692	150	30
3856.704	?	4	3883.140	80	15	3915.64	—	1*h*
3857.39	2	—	3884.519	3	1	3916.40	1*d*	—
3857.63	1*h*	—	3885.453	150*c*	30*c*	3917.014	4	1
3858.00	1	—	3885.686	100	20	3917.30	1	—
3858.953	40	6	3886.074	20	5	3917.584	2*h*	—
3859.237	4*c*	—	3886.664	6*h*	2*h*	3918.115	1	—
3860.48	1	—	3887.32	—	15*c*	3919.005	10	2
3860.694	1	—	3888.29	3	—	3919.163	15*c*	2
3860.860	12*c*	2*c*	3888.49	1	—	3919.718	6	100
3861.081	3*c*	—	3888.68	2	1	3920.198	100*c*	15*c*
3861.384	2	—	3889.14	1	—	3920.754	1	50*h*
3861.519	1	—	3889.440	1	—	3921.34	—	10*h*
			3889.64	8*c*	5*c*	3921.671	6	1
3861.77	—	1						
3862.926	20*c*	2*c*	3890.756	6	2	3922.280	4	1
3863.056	7	150	3891.302	60	10	3922.353	12	3
3863.383	50	5	3892.33	5	2	3923.80	4	1
3863.60	6*c*	—	3892.76	4	1	3924.02	—	2*h*
3863.78			3892.87	4	1	3924.474	12*c*	3
3864.111	1	—	3893.325	6	2	3924.995	40*c*	7*c*
3864.364	8	2	3893.733	40	7	3925.18	4*c*	1*c*
3864.698	1	—	3894.039	50	10	3925.53	3	1
3865.019	—	100*h*	3894.33	1*d*	—	3925.622	2	1
			3894.564	—	5*h*	3926.203	1	—
3865.041	10*d*	—						
3865.96	1	—	3894.70	10	2	3926.618	9	2
3866.24	4	1	3894.99	1	—	3926.903	1	—
3867.393	1	—	3895.36	1	—	3928.265	2	1
3867.918	50*c*	10*c*	3895.895	20	4	3929.296	30*c*	6
			3896.00	4	1	3930.022	—	10*h*
3868.570	8	2						
3868.829	9*d*	2	3896.31	1	—	3930.09	1	—
3869.23	2	—	3896.45	1	—	3930.81	—	2*H*
3869.586	1	—	3898.01	5	—	3931.460	8	2
3870.60	—	6*h*	3898.292	8	200	3931.590	—	2
			3898.563	20	3	3931.79	1	30*h*
3870.665	5	—						
3870.936	—	4	3898.94	4	1	3931.933	3*h*	—
3871.188	20*c*	4*c*	3899.24	15*c*	5*c*	3932.59	1	—
3871.76	5	1	3900.547	2	5	3933.013	6	1
3872.44	1*h*	—	3900.83	5	1	3933.392	8	2
			3901.15	1	—	3934.142	12*c*	2*c*
3872.742	2*c*	1						
3873.288	5	2	3901.73	1*h*	—	3934.405	20	3
3873.686	1*h*	—	3901.88	3	1	3934.64	2	1
3874.106	2	1	3902.39	1*h*	—	3934.81	2*h*	1*h*
3875.10	1	—	3902.829	4*c*	1	3935.441	20*c*	4*c*
			3904.188	30*c*	10*c*	3936.02	4*c*	150*c*
3875.421	10*d*	2	3904.83	2	1	3936.442	10	2
3875.697	5	—	3906.35	1*h*	—	3937.437	150	15*c*
3875.77	20	3	3906.900	12	4	3937.961	20	3
3876.236	1	—	3907.07	1*d*	—	3938.547	—	100*h*
3876.376	1	—	3907.34	1*d*	—	3939.26	3*c*	—
3876.810	4	1	3908.592	8	2	3939.77	1*h*	—
3876.964	20*c*	4*c*	3908.739	—	4	3940.074	1*d*	—
3877.557	60*c*	10*c*	3908.971	40	5	3940.790	2	—
3878.082	1	—	3909.215	3	—	3940.977	2	1
3878.817	40	6	3909.331	—	6*h*	3941.266	40*c*	6*c*

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
3941.611	4	1	3969.130	—	60*h*	4006.995	—	5*c*
3942.905	—	4*h*	3969.93	1*h*	—	4008.286	30	6
3943.663	60	10	3970.10	4*h*	1*h*	4009.533	1	—
3944.417	4*h*	1*h*	3970.650	12	3	4009.707	20	4
3944.730	2	—	3971.055	2	—	4010.10	—	3*h*
3944.90	2	—	3971.35	1	—	4010.581	1	—
3946.29	2	—	3971.679	—	30*h*	4012.056	6	—
3946.98	1	—	3971.852	20	3	4012.165	—	80*h*
3947.319	1	—	3971.932	15	2	4012.902	—	8*h*
3947.516	20	5	3972.25	—	2*h*	4013.101	4*c*	—
3947.922	4*h*	1*h*	3972.52	40*c*	15*c*	4013.268	20	5
3948.082	1	—	3973.624	20*c*	3	4013.942	4	2
3948.240	2	—	3973.87	2*d*	1*h*	4014.646	3	1
3948.433	—	5*h*	3975.20	6*h*	2*h*	4014.922	6*c*	3*c*
3949.326	8	1	3976.268	1	—	4015.748	3	1
3949.451	4*c*	60*h*	3976.52	1	200*h*	4016.06	—	3*h*
3949.70	—	1*h*	3976.677	15*c*	3*c*	4016.070	10*h*	—
3949.927	9	2	3977.940	20*c*	7*c*	4017.558	15	5
3950.966	4	1	3978.753	12	3	4017.793	2	1
3952.367	6	100*h*	3978.909	4	1	4018.995	—	4*h*
3953.015	4	—	3979.370	10	3	4019.13	2	1
3953.071	10	3	3980.483	60*c*	10*c*	4019.79	—	1
3953.524	2*h*	5*h*	3981.323	—	2*h*	4020.233	6	3
3954.18	1	—	3982.055	10*c*	3*c*	4021.016	4	2
3954.583	1*d*	—	3982.53	1*h*	—	4022.387	9*c*	3*c*
3955.38	1	—	3983.11	1*h*	—	4023.141	12	3
3955.55	1	3	3983.939	—	10*h*	4023.275	8	2
3955.680	20	2	3984.810	6	2	4023.41	2	—
3955.84	1	—	3985.074	4	2	4023.427	—	4
3955.882	—	30+N	3985.18	6*c*	2*c*	4024.26	2	1
3956.40	3*c*	—	3986.17	4*c*	—	4025.88	4	1
3956.626	3*c*	—	3988.158	20*c*	7*c*	4026.33	—	7*h*
3956.656	—	5*h*	3989.17	—	2*h*	4026.41	5*c*	—
3956.83	7	2	3989.52	1	1	4026.71	4	1
3957.724	1	—	3990.665	6	2	4026.93	1*h*	—
			3990.926	1	—			
3958.129	7*c*	2*c*	3991.677	40*c*	8*c*	4027.311	12	4
3959.144	3	1	3992.165	4	1	4027.972	15*c*	5*c*
3959.356	15*c*	4*c*	3992.55	1	—	4028.865	4*d*	1*c*
3959.54	2	—	3992.65	1	—	4029.223	6	2
3959.978	4	1				4029.824	1*c*	—
3960.636	4	1	3993.36	1	—	4030.348	10*h*	2*h*
3960.994	10*c*	3*c*	3993.48	—	3*h*	4030.864	—	3
3961.62	—	10*h*	3994.420	6	—	4031.317	—	6*h*
3962.154	4	—	3994.46	—	3*h*	4032.524	150	25
3962.163	—	8*h*	3995.588	3	—	4032.71	1	—
3963.03	1	—	3996.95	1	—	4033.195	40	6
3963.22	3*h*	—	3997.157	4	—	4034.178	1	—
3963.58	—	4*h*	3997.335	—	2	4034.527	6*h*	1
3963.60	3	—	3997.377	4*h*	—	4035.095	10	2
3964.26	1*c*	60*h*	3997.780	2*d*	—	4035.923	12	2
3964.512	1*d*	—	3998.23	4	1	4036.25	1	—
3964.665	7	2	3998.447	7	2	4037.356	4*h*	—
3965.53	2	—	3999.182	40	8	4037.67	—	40*h*
3965.692	40	6	3999.47	—	2	4038.172	8*h*	1*h*
3966.094	25	4	3999.71	2	8	4039.094	15	3
3966.246	100	?	3999.868	1	—	4039.530	60*c*	12*c*
3966.276	?	80*h*	4000.446	1	—	4039.804	1	—
3967.36	—	40*h*	4000.605	4*c*	80*h*	4040.468	8	3
3967.441	1	—	4001.135	15*c*	3*c*	4040.618	3	—
3967.61	1	—	4002.25	4*h*	2*h*	4041.39	1	—
3967.95	—	3*h*	4003.26	—	1*h*	4041.53	1	—
3968.11	1	—	4005.13	2	1	4042.572	10	2
3968.32	7*c*	1	4005.900	?	5	4043.169	10*c*	2*c*
3968.465	5*c*	—	4005.915	4	—	4044.103	25	5
3968.89	1	—	4006.05	4*d*	1*h*	4044.58	1	—

TABLE 2.—*Arc and spark spectra of columbium (Z=41)*—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
4044.712	12	3	4080.82	2*h*	—	4118.93	1*h*	—
4045.06	—	1*h*	4081.38	1*h*	—	4119.284	7	100*h*
4045.580	—	4*h*?	4082.14	1	—	4119.69	1*h*	—
4046.27	4*h*	1*h*	4082.65	—	5*c*	4119.74	—	10*h*
4047.964	—	3*h*	4083.776	5	1	4121.060	3*c*	1
4048.01	3	—	4084.177	10	2	4122.03	—	2*h*
4048.675	—	6*h*	4084.861	40	8	4122.804	15	5
4048.70	1	—	4084.951	4	—	4123.812	400	60
4048.95	3	1	4085.35	1	20*h*	4125.243	20*c*	5*c*
4049.759	20	6	4086.630	9	2	4125.573	12	3
4049.90	—	3	4087.048	6	1	4126.180	2	20*h*
4051.001	6	1	4087.583	1	—	4126.903	8*c*	3*c*
4051.285	1	—	4088.443	2	—	4127.458	12*c*	4
4051.513	25	5	4089.41	—	10*h*	4127.69	1	—
4052.132	6*c*	2*c*	4090.163	20	5	4127.93	1*h*	—
4053.161	6	2	4090.60	3*c*	—	4128.654	2	1
4054.23	1	—	4091.67	3	1	4129.000	4	2
4054.513	—	4*h*	4092.18	1*h*	—	4129.430	100*c*	15*c*
4055.186	8*c*	3*c*	4092.536	6*h*	1*h*	4129.931	150*c*	30*c*
4055.426	2	1	4093.926	6	2	4131.53	6	4*c*
4055.854	4*c*	2*c*	4094.095	6	2	4131.60	3	—
4056.941	8	2	4094.31	1	—	4131.74	2	—
4057.267	6*c*	2*c*	4095.082	8*h*	1*h*	4132.175	3*c*	1
4058.933	2,000*c*	200*c*	4095.553	7	2	4132.67	1*h*	—
4059.498	40	4	4095.930	6*h*	20*h*	4133.40	5*h*	—
4059.68	2	10	4096.28	—	2*h*	4134.33	1	—
4059.83	—	2	4096.314	5*h*	—	4134.592	30	7
4059.85	5	—	4097.63	10*c*	1	4134.985	6	2
4060.32	10	4*c*	4097.93	—	2	4135.423	10	3
4060.37	4		4098.220	10	2	4135.57	4	1
4060.800	40*c*	10*c*	4098.87	5*h*	—	4136.67	1*c*	—
4061.255	9	3	4099.067	30	6	4136.72	—	3*h*
4061.427	4	1	4100.11	1	—	4137.090	200	30
4061.542	10	2	4100.30	3?	—	4137.590	12*c*	4*c*
4061.98	4	60*h*	4100.389	80	15	4138.300	10*c*	2
4062.21	2	—	4100.918	600*c*	100*c*	4138.46	2	10*h*
4063.09	1*h*	—	4101.38	—	3*h*	4138.91	—	2
4063.734	1	10*h*	4103.43	1*h*	—	4139.088	6	2
4064.058	—	15*h*	4103.74	3	—	4139.430	90*c*	10*c*
4064.802	10	3	4104.165	4	50*h*	4139.702	400*c*	50*c*
4065.738	1	—	4104.71	1	—	4140.43	2	—
4066.120	12	4	4105.47	1	—	4140.59	—	6*h*
4067.159	15	4	4106.173	12	3	4141.32	4	—
4068.258	40*c*	15*c*	4106.778	6	1	4142.243	9	3
4068.712	—	5	4106.99	—	2*h*	4142.80	2	—
4069.16	2*h*	—	4107.05	3*c*	—	4143.201	80*c*	10*c*
4070.040	6*c*	—	4107.67	1*h*	—	4143.58	4*c*	—
4070.965	20	4	4108.71	3	—	4143.931	5*c*	1*c*
4071.49	1	—	4109.00	—	4*h*	4144.419	1	—
4071.59	2	—	4109.88	4	1	4145.155	3*c*	1*c*
4072.064	5	15	4110.12	2	—	4146.000	10	2
4072.13	2	—	4110.32	2	20*h*	4146.35	1	—
4073.09	2*h*	20*h*	4110.81	—	8*h*	4146.598	1	—
4073.513	6	1	4112.130	20*c*	8*c*	4146.989	—	4*c*
4073.641	6	1	4112.49	1	—	4147.184	25*c*	6*c*
4074.110	—	1	4113.348	6	3	4148.321	6	2
4074.66	—	2	4113.941	25	7	4148.550	—	4*c*
4076.09	8	1	4114.155	6	2	4148.735	15	3
4077.09	15*c*	3*c*	4114.56	—	10*h*	4149.721	4	1
4077.405	4	1	4115.597	—	10*h*	4150.124	100	25
4078.345	6	1	4115.90	1*h*	—	4152.040	20*c*	4*c*
4078.60	7*c*	—	4116.274	2	1	4152.575	500	80*c*
4079.10	—	10*c*	4116.401	5	1	4154.826	6	2
4079.34	—	6*h*	4116.895	50	10*c*	4155.36	4*c*	2*h*
4079.726	1,000*c*	100*c*	4117.824	2	1	4156.678	4*c*	100*c*

TABLE 2.—*Arc and spark spectra of columbium (Z=41)*—Continued

λairA	Intensity and character		λairA	Intensity and character		λairA	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
4157.008	2c	—	4198.370	10c	3	4248.07	1h	—
4158.007	20	5	4198.510	30	5	4248.658	8	2
4158.820	1	—	4198.672	1	—	4248.961	3	1
4159.49	1	1	4198.847	10	2	4249.457	20	6
4160.806	8	2	4198.90	2	—	4252.977	80c	20c
4161.252	20c	7c	4199.189	6	—	4253.695	50c	10c
4161.884	3c	1c	4199.23	—	8h	4254.05	—	5h
4162.817	12c	4c	4200.993	7	2	4254.392	3c	30c
4163.474	40	6	4201.519	40	10	4254.693	30	5
4163.658	250	50	4202.013	6	1	4255.439	60c	20c
4164.661	300	60	4202.50	1	—	4255.943	20c	6c
4165.330	4c	—	4202.880	—	2h	4256.303	4	2
4165.850	20	5	4203.08	1	—	4257.853	5	2
4166.045	6	2	4203.415	7	2	4258.120	1	—
4167.44	3c	1h	4203.732	1	—	4258.917	12c	4
4168.122	250c	50c	4203.825	1	—	4259.206	2	1
4169.565	30c	6c	4204.322	10	2	4260.661	5	2
4169.72	2	—	4205.308	120	30c	4261.717	20c	5c
4170.909	3c	—	4206.127	10	3	4262.056	100	20
4172.34	1c	—	4206.70	1h	—	4263.164	1h	—
4172.54	—	6h	4208.156	30	8	4264.612	4	2
4173.955	12c	4	4209.708	1	—	4264.90	2	1
4174.047	3	—	4212.042	12	4	4265.83	1	—
4174.342	15	4	4212.535	15	5	4266.020	50	10
4174.894	5	1	4213.256	10c	3c	4266.27	—	8h
4175.506	1h	—	4213.463	10c	3c	4266.835	1	—
4175.76	2c	—	4214.70	?	10c	4267.65	—	20h
4176.166	1	—	4214.732	100c	?	4268.070	1	—
4176.78	1h	—	4214.81	?	20	4268.667	15	5
4177.435	4	1	4215.13	1h	—	4269.92	—	5h
4177.554	1c	—	4216.228	4	50h	4270.691	50c	20c
4177.873	—	5c	4217.946	150c	25	4272.027	4c	2c
4178.088	2	—	4218.53	1	30h	4272.972	8	4
4178.40	1	6h	4219.390	1	—	4273.357	5	3
4179.233	2c	—	4220.598	2	15h	4274.692	20	3
4179.763	12	4dl	4222.676	9	2	4274.87	1	12h
4179.826	4		4224.690	5c	2	4277.500	20	5
4180.992	1	—	4225.177	2	1	4278.18	1	—
4181.048	2	—	4225.85	1	—	4279.49	20	6d
4181.341	15	3	4226.190	6	?	4279.53	5	
4181.52	—	2	4226.22	?	3c	4279.707	8	3
4181.784	6	1	4226.245	6	—	4280.38	1	—
4183.39	—	7h	4226.528	8c	3	4280.586	30	10
4183.910	2	—	4226.96	2c	1	4281.120	2	1
4184.440	50c	15c	4227.514	8	3	4282.968	3	1
4185.54	1	50h	4228.726	8c	1c	4283.055	3	1
4185.66	3	—	4229.154	100c	30c	4283.906	1	—
4186.104	15	4	4229.570	1h	—	4284.14	1h	—
4188.098	3c	—	4229.832	25	5	4284.683	1h	—
4189.250	3c	—	4230.320	20	5	4285.31	1	—
4189.312	—	2	4231.624	1	—	4285.842	2	1
4189.47	—	1	4231.954	25	5	4286.216	15	5
4189.59	3c	—	4233.160	1	—	4286.987	60	15
4189.997	12	3	4236.40	1	—	4288.12	1	—
4190.655	20c	4c	4236.998	4c	1	4288.299	6	2
4190.889	150c	25c	4237.814	12c	13	4288.429	1	—
4192.065	100c	15c	4238.118	1	—	4289.443	30	8
4193.42	1	—	4241.077	4	1	4289.85	4	—
4193.80	—	10h	4241.453	12	3	4290.35	—	2h
4193.828	10c	—	4242.637	20c	6	4291.195	25	6
4195.096	80	20	4244.26	1	—	4291.344	1	—
4195.515	4	1	4245.15	1	—	4292.035	20c	5c
4195.660	15	4	4246.293	20	6	4292.480	40c	15c
4196.948	9c	2c	4246.628	1	—	4293.86	—	—
4197.615	7c	2	4247.689	4c	2	4294.33	1	4c

TABLE 2.—*Arc and spark spectra of columbium (Z=41)*—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
4295.253	1	—	4337.561	12c	3c	4396.77	—	3h
4295.620	15	5	4338.698	6	2	4397.036	10	3
4295.71	—	4	4338.808	2	1	4398.55	—	7h
4296.159	20c	8c	4339.95	1	—	4400.368	10c	4c
4296.44	—	2h	4342.460	7	2	4400.832	10	2
4296.726	1	—	4342.818	25	7	4401.172	2	50h
4297.526	1	—	4345.29	9	6c	4402.056	7c	3
4297.920	6	2	4345.34	10		4403.925	2	1
4298.101	2	—	4345.518	6c	3c	4404.74	1	—
4298.43	1h	—	4346.120	10	4	4406.546	10c	3
4298.699	1	—	4346.43	3Bl	—	4407.26	1	—
4299.45	—	3h	4347.312	8c	2	4407.78	—	5h
4299.596	100	20	4348.244	1c	6h	4408.729	1h	10h
4300.53	—	10h	4348.652	40c	6c	4410.214	60	15
4300.57	1	—	4349.026	30	5	4410.674	1	—
4300.989	100	15	4350.302	9	3	4410.882	2	1
4301.204	4	2	4351.573	40	10	4411.526	15	5
4301.678	1	—	4351.88	1	—	4412.184	5	2
4302.435	3	1	4352.243	2c	—	4413.000	2	—
4302.91	1	8h	4352.52	1	—	4413.15	—	6h
4303.875	9c	3	4352.66	2	—	4414.879	8c	—
4304.659	4c	2c	4353.266	20	4	4415.080	2	—
4306.283	15	4	4354.006	3	2	4416.406	6	2
4306.70	1	—	4354.188	6	3	4416.879	2c	—
4306.99	—	7h	4354.784	4	2	4418.166	1	—
4307.233	2c	—	4355.245	5c	2c	4419.448	40	10
4308.117	15c	6c	4356.847	7	3	4419.839	10	3
4308.692	20c	5c	4359.865	40c	20c	4420.455	10	3
4309.564	20	6	4360.504	5c	4h	4420.637	30c	8c
4310.826	4	2	4361.34	—	3h	4421.305	2	—
4311.27	50c	30c	4361.656	9	3	4421.660	—	20h
4311.37	20		4367.387	2	20h	4423.868	6c	2
4311.695	15	5	4367.966	7	100h	4424.66	—	30h
4312.121	4	1	4368.434	50	10c	4426.27	—	2h
4312.454	25	6	4369.618	8	2	4426.690	20	4
4312.70	—	5h	4370.361	15	4	4427.05	—	10h
4312.88	1	1	4372.645	1c	40h	4427.683	—	4h
4313.887	10c	5	4374.60	—	3h	4427.866	1	—
4314.262	3	1	4374.789	12c	3c	4428.576	2	—
4315.144	1	—	4375.246	6	3	4429.446	20c	6c
4316.476	12c	3c	4376.707	4	2	4430.029	1	—
4316.756	1	—	4377.20	2	2	4432.912	2c	—
4317.72	—	40h	4377.823	5	2	4433.496	3c	1
4318.010	10	2	4377.958	30c	10c	4433.895	1	—
4319.147	3	1	4379.394	2	1	4434.997	3	1
4319.52	1	—	4379.525	12	3	4435.919	3	1
4320.800	6	2	4380.654	4c	2	4436.712	5	2
4321.49	1	50h	4381.114	10c	5c	4437.218	100c	60c
4321.88	3c	1	4381.98	1	—	4437.918	7c	4c
4322.148	1	—	4382.496	7	3	4439.38	1c	—
4322.765	1h	—	4382.856	9c	3c	4440.435	5	2
4323.466	8	3	4383.70	1	1	4441.61	3c	1
4326.320	100c	30c	4384.870	15c	5	4441.802	10c	2c
4326.540	9	3	4385.790	1	—	4442.41	—	3h
4327.385	25c	8c	4386.302	4	2	4443.00	—	5h
4328.428	30c	9c	4387.743	15	4	4443.05	1	—
4329.47	4c	2c	4388.357	30	8	4443.302	2	1
4329.732	20c	5c	4389.496	2	1	4443.80	2	—
4331.252	2	—	4390.63	1	3h	4444.26	1	2h
4331.371	60	15	4391.214	7	3	4444.92	1	—
4332.17	1	—	4391.59	4c	2h	4445.17	—	2h
4332.428	5	2	4392.692	30	10	4445.843	15c	3
4334.23	2h	1	4394.229	3	1	4446.181	12	3
4335.011	1	—	4394.58	1	1	4446.232	4	—
4336.548	6	2	4395.61	1	—	4447.184	100	10

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
4447.737	—	10*h*	4515.93	—	6*h*	4575.372	12	5
4448.06	2	—	4516.914	5	2	4578.52	2*h*	2*h*
4448.769	6	2	4519.02	2	1	4579.446	6	150*h*
4449.912	2	50*h*	4520.40	2	1	4580.50	—	5*h*
4454.68	3*c*	2*c*	4520.836	5	2	4581.623	100	50*c*
4456.331	4*c*	2*c*	4521.132	1	—	4582.283	20	6
4456.800	30	6	4521.703	1	—	4582.87	2	1
4457.424	50	10	4522.21	—	30*h*	4583.132	4	2
4458.117	15	5	4522.545	6	2	4583.49	7*c*	3*d*
4459.01	1	—	4523.409	200	30	4584.10	—	6*h*
4459.671	2	1	4523.727	5	2	4584.849	6*c*	2*d*
4460.17	—	12*c*	4524.127	20	5	4586.31	2	—
4460.203	15*c*	—	4526.425	1	—	4586.73	—	2*h*
4460.423	20*c*	8	4526.52	—	3*h*	4589.00	—	30*h*
4461.49	1	—	4527.648	5	50*h*	4592.42	4	1
4461.92	—	2*h*	4529.250	2	—	4593.79	—	50*h*
4464.151	20	6	4529.415	6	2	4594.48	1*h*	1*h*
4465.232	4	1	4530.43	1	—	4594.97	1	—
4465.926	7	2	4532.47	3*c*	2*c*	4598.01	—	1*h*
4466.198	2	1	4532.76	2	1	4599.475	10*c*	5*c*
4466.421	5	2	4523.28	—	2*h*	4600.22	30	15
4467.92	—	20*h*+O	4533.92	3*d*	2*d*	4600.95	2	1
4468.54	1	—	4534.715	2	1	4602.48	2	1
4468.644	2	1	4535.69	—	8*c*	4602.864	7	3
4469.322	10	3	4537.33	2	1	4603.797	5*c*	2*c*
4469.714	40*c*	12*c*	4537.59	5*c*	2*h*	4605.649	4	3
4471.292	50*c*	20*c*	4540.10	4*c*	—	4606.760	200	80
4472.536	40*c*	10*c*	4541.35	2	1	4607.28	1	—
4472.874	2	1	4541.863	4	2	4608.04	—	2
4474.66	—	7*h*	4542.797	12*c*	4*c*	4608.567	9*c*	4
4475.278	6	3	4543.60	1	1	4609.90	1	8*h*
4475.95	4	2	4543.72	4	2	4610.106	4	1
4476.498	4*c*	2*c*	4546.820	120	30	4610.698	7*c*	3*c*
4477.585	3	2	4547.847	8	3	4612.02	2	2
4478.118	3*c*	2*c*	4548.71	—	10*h*	4612.108	8	4
4480.362	4	2	4550.10	—	50*h*	4612.465	4	3
4481.01	—	2*h*	4550.65	3	2	4614.740	5*c*	3
4481.445	8	3	4551.03	4*d*	2	4616.162	50	20
4482.877	4	2	4551.52	3	1	4617.655	—	4*c*
4484.76	2	—	4551.909	5	2	4618.41	—	2*h*
4484.85	1	—	4553.839	30	10	4619.04	—	1
4485.97	—	2*h*	4554.422	1	—	4619.42	3	2
4487.358	1	1	4555.556	3	1	4620.02	2	2
4489.33	2	1	4556.68	—	3*h*	4622.338	6	3
4489.71	—	2	4556.854	15	7	4623.43	—	1
4490.35	2	1	4559.429	5	3	4623.98	—	1
4491.041	4	2	4560.88	1*h*	1*h*	4624.576	4*c*	2*c*
4491.913	2	1	4561.47	4*c*	2*h*	4625.335	1	2
4492.962	3	200*h*	4562.33	2	2	4625.955	2	2
4494.545	10	4	4564.205	6*c*	3*c*	4627.03	1	2
4495.46	—	8*c*	4564.530	60	20	4627.477	7*d*	6*h*
4497.25	5	2	4566.26	—	3*h*	4628.66	—	2
4498.16	—	4*c*	4566.57	2	1*h*	4630.115	100	50
4499.805	20	8	4567.11	4	2	4630.30	3*h*	—
4500.50	2*c*	2*c*	4567.34	2*h*	2*c*	4631.976	3	2
4501.74	1	1	4567.67	1	—	4632.25	1	1
4503.040	50	20	4569.15	6*c*	2*c*	4632.85	—	4
4503.416	10	4	4569.49	4	3	4633.21	1	3
4507.24	1	—	4570.02	2*h*	1*h*	4633.80	5*c*	2
4508.409	15	5	4570.960	6	3	4636.728	—	2*h*
4510.61	5*Bl*	—	4571.89	1	—	4637.575	—	20*h*
4511.084	30*c*	10	4573.077	200*c*	60*c*	4638.105	10	6*d*
4512.130	7	3	4574.338	7	3	4638.17	4	
4512.65	2*c*	2*c*	4574.572	2	1	4640.248	5	2
4513.44	3*c*	2*c*	4574.848	25*c*	10*c*	4642.46	3	—

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
4643.315	10	3	4695.93	2	2	4772.79	5c	2c
4643.682	10c	1	4696.62	—	1*h*	4773.24	20c	9c
4643.86	5c	3	4697.468	30	15c	4773.80	—	7
4645.405	2	1	4597.752	4	2	4776.07	2	1
4645.84	4c	2	4698.138	—	1	4776.224	2	1
4646.952	20c	10c	4698.506	—	1	4777.62	6c	3c
4647.54	2	2	4699.58	—	150	4780.07	1	2
4648.949	100	40	4700.30	—	1	4780.98	5c	—
4649.255	40	20	4700.91	—	2c	4782.17	1	1
4649.622	2	—	4701.49	—	1	4782.44	—	1
4650.01	1	—	4702.02	5	4c	4782.948	4	2
4652.08	3	—	4702.70	—	1	4784.30	5c	2c
4652.19	—	10*h*	4703.32	—	1*h*	4785.697	7	3
4653.802	2	1	4703.92	4?	3	4787.56	1	1
4654.89	1	—	4704.60	—	1	4787.73	3	2
4655.30	—	6*h*	4705.09	4	3	4789.80	—	5*h*?
4655.953	1	1	4706.132	100c	70c	4789.959	25	100
4658.186	12	4	4707.103	5*d*	2	4790.58	6*d*	3c
4660.41	—	10*h*	4708.284	150	100	4790.902	9	4
4660.70	3*h*	1	4711.872	6*d*	3c	4791.48	—	4*h*
4660.98	5*h*	2	4713.038	9c	4c	4793.07	5c	2c
4662.89	4c	1	4713.495	80	20	4794.59	—	1
4663.131	2	1	4715.819	20	8	4798.818	2	1
4663.831	100	40	4717.52	—	2c	4800.07	—	2
4663.97	4?	2	4718.024	8	5	4802.442	9	3
4664.366	5	2	4720.10	2	2	4803.83	—	1
4665.333	10	3	4723.146	3	2	4805.16	—	1
4665.60	—	6*h*	4723.795	15c	7c	4805.61	3	2
4666.251	100	50	4724.48	2	1	4806.63	—	1
4666.630	6c	4c	4726.09	—	1*h*	4807.052	10	5
4666.96	—	1*h*	4726.77	4*d*	2c	4809.03	4c	4*d*
4667.224	50	20	4727.320	10c	5	4809.12	4	
4668.232	6	2	4730.312	20	6	4809.357	30	12
4668.966	3c	—	4733.483	30c	10c	4810.584	100c	50c
4669.08	—	4*h*	4733.885	60c	40c	4811.287	12c	5c
4669.32	2c	2*h*	4735.04	—	2	4812.12	2	1
4669.868	10	5	4735.339	10	3	4814.98	2	1
4670.104	1	100	4736.49	20c	8c	4816.375	80c	40c
4670.87	3c	2c	4740.426	2	1	4820.07	1	1
4672.097	200c	100c	4740.61	15c	5c	4821.11	3	1
4673.589	12c	3c	4742.072	3	1	4822.93	—	2
4674.378	2	1	4742.43	4c	2c	4824.17	1	12*h*
4675.371	150	60	4743.839	15	5	4824.954	6c	3c
4676.29	1	—	4744.622	30	20	4826.50	1	—
4677.072	2	—	4745.020	10c	3c	4826.97	1	1
4678.44	10	8*d*	4746.987	9c	3	4829.302	30	15
4678.51	12		4748.04	3h	1	4830.69	2	1
4680.890	4c	3c	4748.84	3c	2c	4832.21	3	1
4681.53	1	3c	4749.706	200c	150c	4833.362	40	15
4681.66	3		4750.74	5	1	4835.56	—	1
4681.997	2	1	4751.44	20	8	4836.44	—	2*h*
4682.664	10c	4c	4752.10	5*h*	1*h*	4837.615	15	5
4682.984	7	3	4752.86	1	1	4837.98	20c	8c
4683.68		1	4753.48	3*d*	—	4840.28	1	1c
4685.133	100	40	4754.957	5	2	4840.39	1	
4685.518	9	3	4755.318	10c	6c	4842.139	20c	8c
4685.925	9	3	4756.538	4	2	4845.170	20	8
4687.19	1*h*	—	4757.22	—	3c	4845.46	2	1
4687.790	3	2	4758.12	2c	2c	4847.39	3*h*	2*h*
4688.49	4*B*?	1	4766.53	6	3	4848.02	—	1
4688.83	5c	—	4766.80	30c	20c	4848.359	100c	70c
4689.162	10	2	4767.07	5	2	4849.35	2	1
4692.255	3	2c	4768.23	—	3*h*	4851.881	7c	3
4694.50	15c	6c	4771.852	7	3	4852.101	—	4
4695.46	20c	10c	4772.20	1	1	4852.273	6	3

TABLE 2.—*Arc and spark spectra of columbium (Z=41)*—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
4853.89	1	1*h*	4976.75	—	1	5116.741	5	2
4854.738	—	3*h*	4985.18	1	1	5118.065	3	1
4854.960	—	3*h*	4988.972	40	15	5120.298	20	8
4857.31	1*h*	1*h*	4991.38	1	—	5120.492	—	2*h*
4858.46	1	2*h*	4992.466	6*c*	2	5121.801	12	4
4860.994	2	2	4993.232	3	1	5124.694	4*c*	2*c*
4865.99	1	12*c*	4993.83	1	2	5127.662	9	3
4866.842	12*c*	4*c*	4994.303	12	7	5128.278	2	1
4868.99	20	10	4997.880	15	6	5129.74	1	1
4870.32	1	1	5000.712	4	2	5133.338	7	2
4872.505	5	2	5000.958	20*c*	10*c*	5134.752	40	15
4878.496	5	2	5002.247	12	6	5135.47	2*c*	1*c*
4879.20	1	1	5006.22	—	2	5137.398	3*c*	2*c*
4880.714	8*c*	3*c*	5008.039	6	3	5140.578	8	3
4881.68	2	1	5011.750	4	2	5140.68	3	1
4885.765	5	2	5013.275	9*c*	3	5145.65	1	1
4889.551	7*c*	3*c*	5017.363	3*c*	1*c*	5146.03	1*c*	1*c*
4889.809	3	1	5017.743	40	20*c*	5147.537	12*c*	5*c*
4890.739	25	15	5019.512	8*c*	3*c*	5147.94	—	4*h*
4891.07	—	2	5026.362	20	10*c*	5149.62	1	1
4892.50	12*c*	6*c*	5028.65	2	1	5150.636	7*c*	3
4893.885	—	15*h*	5029.67	3	1	5152.623	12*c*	8*c*
4895.574	10*c*	4*c*	5030.130	7	3	5153.028	6	3
4897.51	2	2	5031.884	5*c*	2	5153.63	2	1
4898.491	4	3	5035.99	6*c*	3*c*	5157.14	2	1
4900.786	20	7	5037.89	1*c*?	—	5157.486	3	2
4903.02	1*h*	1*h*	5039.032	40	15	5158.030	2	1
4904.534	25	5	5041.77	1	1	5160.335	50	20
4908.331	3*c*	2*c*	5043.030	3*c*	2	5161.63	1	1
4908.716	7*c*	3*c*	5043.47	1*h*	1*h*	5164.368	40*c*	15*c*
4910.948	30	15	5043.985	5	2	5165.368	—	4*h*
4915.31	4*B*?	—	5046.756	3	1	5166.96	1	1
4915.842	7	2	5047.956	12*c*	4	5167.37	1	1
4916.392	15*c*	6*c*	5049.91	2	1	5174.198	3	2
4917.76	1	1	5051.59	1	1	5174.569	2	2
4920.75	3*h*	1	5054.22	1	1	5178.209	3*c*	1
4921.07	1	1	5054.671	8	3	5180.306	50	15
4923.742	—	2*h*	5055.62	2*c*	1	5183.31	—	1*h*
4924.862	6*c*	3	5057.999	40	15	5183.81	1*h*	1*h*
4928.969	15	6	5059.353	10	4	5186.987	15	4
4929.556	5	2	5060.99	1*c*?	—	5189.198	20	9
4932.140	2	1	5064.45	3*c*	2*c*	5193.078	40*c*	15*c*
4933.20	2?	3*c*	5065.256	20	8	5193.454	5	2
4936.66	—	2*h*	5071.66	4*c*	2*c*	5195.839	20	8
4937.45	—	1*h*	5072.56	3*c*	1*c*	5197.37	2*c*	1
4941.513	9	3	5075.97	5*c*	2	5201.089	3	1
4941.905	2*h*	—	5077.391	7*c*	2	5201.938	3	2
4942.00	—	4*h*	5078.959	150	60	5203.224	10	4
4945.432	12*c*	5*c*	5079.314	3	1	5204.03	3*c*	2*c*
4949.439	—	3*h*	5082.31	2	1	5205.132	8	3
4950.07	—	1*c*?	5084.90	5*c*	3*c*	5207.65	2	1
4951.54	1	1	5086.83	3*h*	1	5210.26	2	1
4953.124	7	3	5088.82	9*c*	3*c*	5211.239	4*c*	3*c*
4956.60	3*c*	1*c*	5094.342	3		5215.65	—	2*h*
4957.393	8*c*	3*c*	5094.416	3	3*c*	5218.46	3*c*	2
			5094.485	3				
4957.74	—	8*h*				5219.09	15*c*	8*c*
4960.434	—	1	5095.14	3	1	5225.156	12	5
4962.950	5*h*	2	5095.298	80	25*c*	5229.37	3	1
4963.189	7	2	5095.535	7*c*	2*c*	5229.94	2	1
4965.375	25*c*	12*c*	5096.57	2	1	5232.813	25	10
4967.777	30*c*	20*c*	5097.77	5*c*	1	5235.096	3*c*	2
4969.44	—	2	5098.87	3	1	5236.32	1	2
4971.917	10*c*	3*c*	5100.162	30	10	5236.837	4	3
4973.138	15	7	5102.38	4*c*	2*c*	5237.34	—	5*c*
4975.135	10*c*	4*c*	5110.910	6*c*	2*c*	5237.37	7	—

TABLE 2.—*Arc and spark spectra of columbium (Z=41)*—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
5237.47	9	3	5363.28	1	—	5483.48	8	3
5240.39	5c	2	5365.88	1	100*h*	5484.58	1	1
5241.50	4c	2	5368.390	4	2	5487.60	1	200
5247.38	10c	4c	5371.111	4	1	5491.062	4	2
5251.62	15c	10c	5375.262	8	4	5494.09	5*h*	3*h*
5251.81	10c							
5253.028	10	4	5375.916	3c	1c	5499.53	7	2
5253.926	15	6	5376.722	2	1	5499.87	1	1
5255.52	1c	2c	5377.79	3c	1c	5500.53	1	1
5260.13	3c	2c	5380.705	4c	1c	5501.759	5	2
			5381.326	10	5	5502.45	1*h*	1*h*
5260.849	2c	1						
5269.910	6	3	5382.842	3	1	5504.58	30c	10c
5271.526	60c	30c	5383.87	—	10*H*	5504.79	2	1
5272.48	5	2	5383.99	1	—	5506.74	1c	1*h*
5273.486	—	5*h*	5388.300	6	2	5507.86	1	1*h*
			5393.98	—	10*H*	5509.13	7	3
5276.196	50c	20c						
5277.42	3	1	5394.36	3c	1	5510.19	—	3*h*
5278.542	5	2	5395.483	2	—	5510.69	2*h*	1
5279.418	8c	3c	5395.849	5	3	5511.22	4c	2*h*
5281.62	1	2	5396.33	7c	4c	5512.81	15c	6c
			5400.56	1	—	5517.39	5	3
5285.240	20c	10c						
5285.43	2	—	5402.49	2	1	5521.89	3	1
5287.08	2	—	5403.06	2	1	5523.57	30	15
5293.292	5c	2c	5404.427	2	1	5532.59	4	2
5294.47	2	—	5408.92	—	20*H*	5538.736	3	1
			5409.43	2	1	5540.20	2*h*	1*h*
5296.34	8c	3c						
5298.108	4	2	5411.235	8	4	5541.461	9	3
5298.95	4	2	5416.292	6c	3	5545.52	2c	—
5301.434	2	1	5422.42	20	10	5545.63	—	100
5303.27	3	—	5423.48	—	2c	5546.35	—	2
			5427.82	1	1	5549.60	8c	?
5306.380	4c	1c						
5306.606	3	1	5431.25	12*d*	6c	5549.62	?	20*H*
5306.97	2	1	5431.77	1	—	5550.18	2	—
5314.283	3c	—	5432.478	2	1	5551.34	60	30
5315.543	10	5	5433.54	—	50*H*	5552.33	5	2
			5434.46	1	—	5553.115	4	2
5317.001	4	2						
5317.804	5c	3c	5437.265	50	30	5559.34	1	1
5318.597	50	30	5437.998	2c	1c	5562.99	15	10
5319.485	15	6	5439.78	—	50*H*	5566.12	2	1
5320.205	3	1	5443.08	4c	3	5571.41	10c	?
			5443.77	1c	1	5571.43	?	20*H*
5321.323	4	2						
5321.659	2	1	5445.15	4	2	5572.00	—	10*H*
5321.917	2	1	5448.306	8	5	5572.52	2	2*h*
5323.354	3	1	5452.79	2	1	5576.16	15c	8c
5326.341	3c	1	5455.03	—	30	5577.06	1c	1c
			5456.19	6	4	5578.07	4c	2
5331.19	—	10*h*						
5334.27	1c	—	5457.60	—	30*H*	5578.28	15	10
5334.864	30c	15c	5457.66	3	—	5586.99	30	10
5336.797	6	3	5458.043	10c	6	5590.05	—	2*H*
5337.872	4c	2c	5459.51	—	5*H*?	5590.43	1	1
			5460.935	4c	2c	5590.95	15c	7*h*
5339.89	1	1						
5340.793	10	5	5462.03	1	—	5594.87	6c	3c
5343.602	8c	4c	5462.98	1	—	5595.72	—	30*H*
5344.160	200c	100c	5463.95	1	—	5596.87	5*h*	3*h*
5345.55	2c	—	5466.90	2	1	5599.57	10c	4*h*
			5467.41	3	1	5603.51	30	10
5350.723	100c	60c						
5351.022	6	3	5468.10	9	5	5603.93	7	3
5353.283	5	3	5469.55	6c	2	5606.36	2	1
5355.086	3c	1	5471.90	2c	1	5612.30	—	20*H*
5355.300	5	3	5476.07	5c	3	5616.27	1*h*	—
			5477.33	1	1	5616.99	2c	1c
5355.683	9	4						
5356.84	—	15*h*	5477.96	1	—	5618.69	3	1
5359.183	7	3	5478.74	3	1	5619.78	1*h*	—
5362.003	6	2	5479.205	4c	2	5622.09	1½	—
5363.975	4	8?	5481.002	15	8	5628.25	10c	3
			5483.08	5c	2	5629.17	40	20

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
5629.81	6c	2	5794.24	20	10	5971.25	5c	3h
5633.64	2c	2c	5801.01	2c	—	5973.26	—	8h
5635.42	20c	?	5801.78	1h	1h	5979.55	2c?	2h
5635.48	?	20H	5804.02	30d	15	5983.21	100	50
5642.10	80	40	5804.65	4c	1h	5986.08	30	20
5644.66	—	2h	5805.91	1	—	5986.61	5	2
5645.30	10	4	5809.08	1	—	5992.32	2h	1h
5648.40	3c	1c	5810.68	5c	2c	5994.84	2	1
5654.13	5	2	5811.89	3	4	5995.94	1	1
5662.04	1	—	5815.316	15c	6c	5997.86	50c	25c
5664.70	100	50	5819.415	80	50	6000.25	—	6h
5665.63	120	60	5820.01	2	1	6018.96	2	2
5666.86	9	—	5820.61	20c	10c	6021.41	2h	2h
5671.09	60c	40c	5825.41	3	1h	6022.41	—	2H
5671.90	50	20	5828.85	—	4h	6022.50	1	—
5675.942	3	—	5834.40	2	1	6025.29	2	—
5677.453	10	4	5834.88	40	25	6028.73	5c	1h
5684.45	5c	2c	5838.13	15c	6c	6029.74	12	5
5690.78	—	3h	5838.61	100c	60c	6031.83	10	5
5693.07	8	3	5839.17	2	2	6039.95	—	15h
5697.89	5	5c	5842.47	30	15	6041.96	4	2
5698.01	4		5846.10	20c	10c	6045.49	20	10
5706.16	15	8	5848.34	1	—	6047.46	2h	1h
5706.47	50	20	5850.67	2	1	6048.71	10c	5
5708.46	2	1	5851.94	1	—	6052.31	2	1
5709.33	15	6	5852.79	6	3	6052.59	1	—
5712.02	2	1	5855.72	6	2	6054.42	1	1
5713.44	2	1	5856.70	5	2	6056.64	12c	6
5713.79	5c	2c	5858.81	2h	—	6062.17	—	5h
5715.58	6	3	5862.12	4	2	6065.68	1	—
5716.34	30	20	5863.21	2c	1c	6067.81	4	2
5719.62	1	—	5864.12	1	—	6072.60	1	1
5722.70	4	1	5864.43	2	1	6073.02	1	1
5725.66	9	5	5864.94	6	3	6083.55	6	2
5726.13	1h	1c	5866.45	80	40	6091.80	—	5h
5729.185	80	30	5868.89	6	2	6103.49	4c	2h
5730.32	1	1	5872.36	2	2c	6105.30	2	1
5731.99	1h	1h	5872.56	2		6107.69	9	5
5734.35	1c	?	5874.68	40c	20c	6110.94	6	3
5734.43	?	3c	5875.24	7c	3	6118.10	4c	1
5737.35	7	3	5876.30	8c	5c	6119.68	—	5h
5738.19	6	2	5877.78	20	10	6119.80	6Bl	—
5741.79	2	1	5878.97	5	2	6120.09	8Bl	—
5743.384	3	1	5880.68	—	3H	6124.52	5p?	1
5743.847	3c	1c	5885.94	4	2	6128.68	7c	4c
5745.93	1h	—	5893.43	15c	8c	6142.53	7c	4
5746.90	—	20h	5894.61	3	2	6148.11	10c	5
5751.43	40	20	5898.54	1	1	6154.91	5p?	—
5753.06	—	30h	5900.59	200c	100c	6157.83	—	2h
5753.26	3	—	5903.80	20c	10c	6164.30	12	5
5754.44	4c	2c	5904.48	5	2	6175.01	—	2h
5758.11	4h	2h	5910.55	2h	2h	6183.24	—	8h
5759.00	2c	1h	5920.16	1h	1h	6204.75	6	3
5760.33	80	30	5924.27	2h	1	6213.06	8	4
5764.98	40	20	5927.40	10	10	6219.59	5h	3h
5771.06	10c	5c	5928.234	12c	4c	6221.95	20	6
5774.83	4	2	5934.15	15c	10c	6245.08	2h	2h
5776.07	30c	20c	5937.07	1	—	6249.68	1	2
5779.08	2	2	5938.62	2	1	6251.76	20c	10c
5779.78	2	1	5948.69	2h	1	6260.77	8c	4
5780.31	8	3	5949.90	4	2	6275.41	4	3
5782.67	1h	—	5957.69	15	6	6285.81	—	5h
5787.52	80	30	5964.56	1	—	6286.38	6c	3c
5789.78	7c	3	5965.36	4c	2c	6309.24	4c	2h
5790.63	2h	2	5970.67	—	6h	6312.16	5c	1h

TABLE 2.—*Arc and spark spectra of columbium* ($Z=41$)—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
6325.78	4	2	6951.15	10*Bl*	4	7583.21	6	1
6331.51	1	1*h*	6966.89	10*c*	4*c*	7584.06	2	—
6334.10	3*h*	1	6971.61	10	4	7585.28	5*h*	1*h*
6346.24	4	2	6972.49	20	6	7603.40	5*c*	
6348.98	6	3	6975.05	8	3	7639.81	2	
6355.56	2*c*	1	6978.39	6	2	7647.64	4	
6375.95	2*p*?	1	6986.09	20	6	7659.02	2	
6422.06	4*p*?	—	6989.38	5	2	7703.33	6	
6423.76	2*p*?	—	6990.32	100	30	7726.68	60*c*	
6430.46	80*c*	20*c*	6996.11	10*c*	5*c*	7757.31	20	
6433.22	30	6	7014.90	5	2	7772.11	5*h*	
6449.83	5*c*	2	7023.48	30	10	7787.11	3	
6453.11	—	5*H*	7026.15	2	10	7862.68	3*h*	
6464.32	5*d*	4	7035.63	3+*p*	1	7868.58	4*h*	
6473.95	20*Bl*	1	7038.04	10	3	7873.41	25*c*	
6484.36	30*Bl*	—	7046.81	200	80	7885.31	60	
6494.94	8*Bl*?	—	7051.20	8*c*	3*c*	7926.40	1	
6497.84	8	2	7066.41	6	2	7938.89	30	
6544.61	80*c*	20*c*	7075.23	7	2	7952.25	20*Bl*	
6551.61	5*p*?	1	7091.27	5	2	7954.76	10	
6556.92	4	2	7098.94	50*c*	20*c*	7997.80	15*Bl*	
6574.73	8	3	7102.01	30*c*	10*c*	8017.23	5*h*	
6575.9	20*Bl*	3	7119.31	10	4	8045.17	6*B*?	
6591.00	40*c*+*B*	20*c*	7122.95	6	3	8118.17	7*c*	
6606.14	10	5	7126.17	30	10	8118.67	6*h*	
6607.30	10	5	7130.06	10	3	8135.20	80	
6614.15	20	10	7136.09	5*B*?	2	8173.03	6	
6616.68	4	2	7159.43	100	30	8176.23	3	
6626.97	4	2	7165.82	5*c*	1	8181.70	1	
6629.11	1	20*h*	7178.27	8*c*	2	8189.40	3*h*	
6660.84	300*c*	150*c*	7180.01	6	2	8190.66	3	
6677.33	200*c*	100*c*	7186.14	3	1	8211.23	3*h*	
6681.33	5+*p*	2	7191.37	10	3	8226.08	3*h*	
6689.24	3	1	7208.94	15*c*	4	8228.98	3*h*	
6696.44	5	5	7235.68	3*p*?	1	8240.00	50*c*	
6699.82	3+*p*	2	7241.80	5*h*	1	8262.41	3*h*	
6701.20	100	30	7252.35	40	8	8283.6	5*Bl*	
6703.18	5+*p*	2	7256.18	5	1	8320.93	500*c*	
6709.88	10*c*	3*c*	7258.90	7*c*	2	8346.08	60	
6717.55	7+*p*	3*c*	7262.78	2	—	8350.04	10*h*	
6721.96	8	3	7268.90	5*c*	1	8371.39	4*h*	
6723.62	150*c*	50	7274.77	6	2	8373.76	1*p*?	
6726.28	10+*p*	3	7276.76	4	1	8387.88	4*h*	
6728.83	3+*p*	2	7311.93	5*c*	2*c*	8389.36	3*h*	
6737.16	5*Bl*	2*Bl*	7317.03	10	3	8406.23	15*c*	
6739.88	80	30	7323.92	15.	2	8414.74	3	
6745.43	4+*p*	3	7328.38	20*c*	5	8417.08	4	
6769.79	6+*p*	3	7332.30	4	1	8433.90	4*h*	
6795.26	15+*p*	8	7340.25	2	—	8434.31	3*h*	
6828.11	150	50	7353.16	50*c*	15*c*	8439.77	25*c*	
6849.33	25*c*+*p*	10	7382.50	150*c*	50*c*	8453.47	2	
6857.14	3	2	7409.78	2	—	8475.98	150*c*	
6870.92	20	7	7419.83	4	1	8526.99	50	
6876.36	60	25	7428.50	4	1	8547.25	20*c*	
6879.90	10*c*	3*c*	7435.38	3	1	8560.54	30*c*	
6886.33	30*c*	10*c*	7436.02	4	1	8575.87	30*c*	
6888.48	10*c*	3	7452.88	4	1	8614.45	20*c*	
6902.89	50*c*	20*c*	7456.32	4	1	8681.94	2*h*	
6906.59	6	3	7459.07	2	—	8691.45	2*h*	
6908.07	40	10	7478.20	10	3	8695.10	2	
6918.32	60	20	7515.93	40	10	8697.55	40*c*	
6920.85	—	2	7519.77	20*c*	4	8717.09	4	
6929.05	—	4	7532.11	3	1	8740.96	20	
6940.90	7	30	7547.71	3*c*	1	8767.97	12	
6946.07	10	4	7574.58	100*c*	20	8769.57	7*c*	

TABLE 2.—*Arc and spark spectra of columbium (Z=41)*—Continued

λ_{air}A	Intensity and character		λ_{air}A	Intensity and character		λ_{air}A	Intensity and character	
	Arc	Spark		Arc	Spark		Arc	Spark
8782.55	2		9412.39	4		10109.92	4	
8798.22	3		9415.14	2*p*?		10156.57	3	
8799.76	7		9427.45	2*p*?		10181.33	10*c*	
8815.56	100*c*		9435.48	8*c*		10203.44	8*c*	
8896.4	5		9437.52	2*p*?		10229.04	2*p*?	
8897.5	6		9438.7	8*h*		10249.56	5*c*	
8905.78	30		9470.93	6		10272.30	2*p*?	
8913.18	2		9472.02	4		10306.4	2*p*?	
8915.76	4*c*		9474.57	5		10419.54	10*c*	
8930.70	3		9483.38	2*p*?		10436.5	2	
8933.43	6		9518.30	3*p*?		10448.37	3	
8959.75	20*c*		9549.13	8*c*		10452.53	3	
8967.76	20*c*		9568.30	2*p*?		10460.87	3	
8983.15	4		9595.06	60*c*		10496.22	5*c*	
9011.74	7		9598.72	6*c*		10522.7	3	
9039.18	8		9614.72	2		10525.50	5*c*	
9041.27	2*B*?		9620.96	10		10533.72	4	
9042.23	5*B*?		9626.88	100*c*		10563.7	10*c*	
9054.88	2		9631.11	50*c*		10588.70	7	
9061.43	20*c*		9650.97	12		10636.54	4	
9066.54	4*c*		9667.22	2*p*?		10663.3	2	
9084.91	7		9669.8	3		10706.8	3	
9117.68	7		9676.75	50		10863.2	5	
9123.60	3		9677.5	4		10872.6	3	
9125.25	10		9790.64	2*p*?		10907.9	5*c*	
9129.44	10*c*		9798.66	3*p*?		10917.0	2	
9131.6	4*p*?		9815.56	2*p*?		10920.7	5*c*	
9141.31	50*c*		9890.09	4*c*		10994.4	2*p*?	
9186.96	20		9896.6	5		10999.9	3*p*?	
9197.60	15		9910.35	20		11046.1	3*p*?	
9213.8	3*p*?		9912.26	25		11051.0	2*p*?	
9240.9	10*c*		9943.64	2*p*?		11075.7	1*p*?	
9299.2	10+*p*		9957.29	15		11079.7	3*p*?	
9323.54	40*c*		9965.44	4*c*		11134.8	3	
9341.52	3*p*?		9991.33	1		11149.6	3	
9344.4	4		10003.85	30*c*		11262.2	6	
9353.17	10		10019.40	2		11454.4	2	
9359.32	3*p*?		10042.54	10*c*				
9393.56	4		10067.4	20*cd*?				
9408.60	20		10084.46	5*c*				

WASHINGTON, February 13, 1936.